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FIRST REPORT

OF THE

GEOLOGICAL SURVEY OF NATAL AND ZULULAND.

BY

WILLIAM ANDERSON,

GOVERNMENT GEOLOGIST.

Issued by direction of the Hon. Sir Albert Henry Hime, K.C.M.G., Minister of Lands and Works.

SECOND EDITION.

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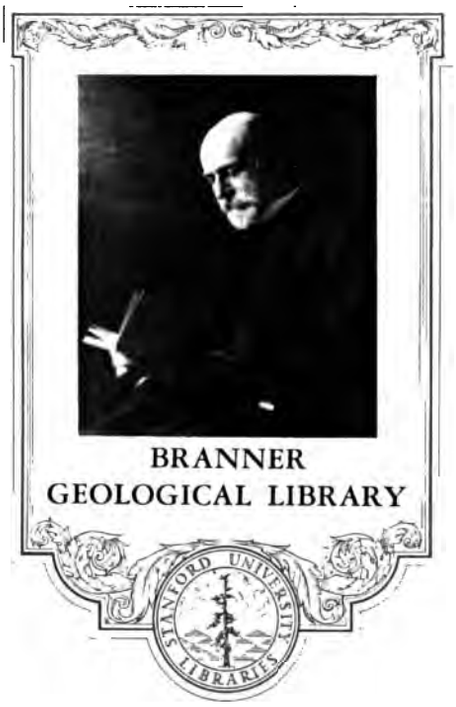
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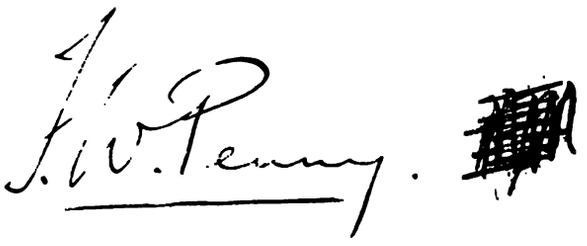

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LETTER OF TRANSMITTAL.

GEOLOGICAL SURVEY OF NATAL,
May 1st, 1901.

SIR,

I have the honour to submit, herewith, the First Report of the Geological Survey of Natal and Zululand. I have found it necessary, chiefly owing to the war and other causes, to include in this report most of the work carried out by me during the two years 1899 and 1900, and therefore some delay has occurred in the preparation of the report for publication. Unfortunately, further delay has been occasioned by the fact that, at the last moment, the necessary plates had to be sent home for reproduction.

Very respectfully, yours,

WILLIAM ANDERSON,
Government Geologist.

J. L. MASSON, Esq.,
Surveyor-General.

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INTRODUCTION.

Having arrived from Scotland in the end of December, 1898, I entered upon my duties, as Government Geologist, on the 1st of January, 1899.

Up to the beginning of October of that year I was engaged for 258 days in the field, but owing to the outbreak of hostilities with the Dutch Republics little or no geological field-work could be accomplished during the last three months of the year.

During the month of January and part of February I visited those parts of the Colony which could be reached by rail, in order to obtain a general knowledge of the presence, occurrence, and local developments of the various geological formations which constitute the geology of Natal.

From the end of February until the end of May I made a beginning with the systematic geological mapping of the Colony. I selected the Lower Tugela or Stanger district, in the County of Victoria, as the area of commencement, with the intention of working southward along the coast, so as to include the belt of country consisting of metamorphic and granitic rocks, which outcrop in the Mapumulu and Inanda divisions, among which there is the possibility of the occurrence of metals of economic value.

From the beginning of June until October I was engaged in Zululand making a reconnaissance geological survey of that Province. Until the war broke out, I was able to traverse the coastal area and a large portion of the northern inland part of the Province.

During the last two months of the year a temporary office was found for me in the offices of the Agricultural Department. I occupied this room until April, when two rooms were secured for the Survey at the back of the Colonial Buildings. These rooms, however, were not furnished until the end of December, 1900.

In the month of January, 1900, I took my annual leave. Until the end of April I was in office. During this period I overhauled the collections of fossils and rock-specimens which I had made in carrying out my field-work in Zululand and in the Stanger district, and prepared a representative collection of the former, which was sent to Mr. R. Etheridge, Jun., Palæontologist and Curator of the Sydney Museum, who kindly undertook to examine and identify them. I also prepared a selection of the rock-specimens, which I sent to Germany for microscopic section. The latter have just been received, and will be examined and described as soon as I can find the necessary time.

From May to the end of November I was engaged in the field mapping the Lower Tugela district, which has now been examined and mapped between the Tugela and Tongaat rivers.

During the month of June I proceeded to Capetown to act as one of the examiners in Mineralogy and Geology for the Cape University.

Towards the end of 1899 I sent out to many Scientific Societies, Institutions, and Geological Surveys, in all parts of the world, a circular-letter, intimating the establishment of a Geological Survey of Natal, and requesting an exchange of their Journals and Reports for those which will be published in the future by the Survey. Owing to the generous manner in which this letter was responded to, a large number of Reports, Transactions, and Monographs, relating to geological subjects, have been acquired. I take this opportunity of thanking those scientific bodies who have agreed to exchange their publications, and thereby lay us under an obligation which it will be difficult to meet. Already over five hundred volumes have been received, and these now form the nucleus of a Geological Library which will, if judiciously looked after, increase and become a useful and important adjunct to the Geological Survey. A reference library of this kind is an absolute necessity in the carrying out of any systematic geological work, and it is all the more reason why, the Geological Survey of Natal should possess such a library, as there is no library in the country, nearer than Capetown, in which there are Geological works of any importance. Although much of the current geological literature is embraced in the publications of Societies and Surveys, a very large amount is contained in the periodicals published both in America and Europe, and I would, therefore, suggest that permisson be given for the annual expenditure of a small sum wherewith to purchase, at least, the principal geological magazines and periodicals, which would form an exceedingly useful addition to the library, and bring the literature of the subject up to date.

Since the initiation of the Geological Survey, I have been the only member of the staff, except that Mr. G. Forder acted as camp assistant during the reconnaissance survey of Zululand in 1899, and Mr. C. Turner acted in the same capacity in the Stanger district, from May to November, 1900. In both cases they performed the duties entrusted to them to my entire satisfaction.

It is to be regretted that it is not possible to obtain the services of, at least, one geological assistant. This subject will, however, be referred to, further on in this report.

No Laboratory work has, as yet, been possible, except of a most cursory kind. A supply of chemicals and apparatus is urgently needed.

I have been able to make a beginning with the microscopical study of some of the crystalline rocks of the Colony, while most of the palæontological collections, made during the last two years are at present under examination. A first instalment of these has just come to hand, and will be published with this report. This deals with the fossil plants, &c., from the coal-measures of Zululand, by Mr. R. Etheridge, Jun., Curator of the Museum, Sydney, N.S.W., Australia. I hope to be able to have the other collections examined and described so that they will be ready for publication in my next report.

While in the northern portion of the Colony, during January, 1899, I visited Harrismith, the terminus, in the Orange River Colony, of the

branch line of the Natal railway from Ladysmith. In the neighbourhood of this town, which is situated on the plateau surmounting the Drakensberg range, over 5,000 feet above sea level, the Cave Sandstones and Upper Karoo Beds are well developed. In many localities on the plateau, these beds are locally fossiliferous, containing quantities of the harder and more indestructible, skeletal parts of reptiles and fishes, with occasional plant remains. These fossils usually occur among the shales and thin-bedded sandstones, but not infrequently, they are present in a good state of preservation in the thick, coarse-grained horizontally-bedded sandstones, whose presence in this series of rocks, has formed, by denudation, those table-topped hills which are so characteristic of this portion of the high veld. Good examples of these occur in the district around Nelson's Kop. These beds, forming, as they do the uppermost and youngest portion of the sedimentary series of the Karoo Formation, are overlaid by a set of contemporaneous basaltic lavas, forming a volcanic series of considerable thickness, which caps the Drakensberg range to the southward, where it culminates in the summit of Mont-aux-Sources, the highest mountain in South Africa, 11,500 feet in height. The effects of denudation upon this volcanic capping of the range and the underlying sedimentary rocks, have produced some of the wildest and roughest country in Natal, together with mountain scenery of the grandest, and often of the most fantastic character. Almost any part of the Natal side of the range exhibits these characteristic features, some to a greater degree than others. When one notes the stupendous gorges, the precipitous cliffs, the rock strewn slopes, and the almost impassable ruggedness of the whole country along the range, together with the marvellous and fantastic forms which have been carved out of the hard, unyielding basaltic rocks and more easily degraded sandstones, by the slow and seemingly insignificant agency of atmospheric denudation, one realises the real significance and importance of that agency, as the chief factor in the production of scenery and the moulding of the surface of the land, to give it those physical features, by means of which it has been converted into a habitable and productive country.

A common feature in many localities along the Drakensberg is the occurrence of native rock-shelters. These have been formed, either where the more easily degraded rocks, below the outcrop of a thick bedded sandstone or volcanic rock, or in some cases the sandstone itself, have been hollowed out by denuding agencies. This natural excavating has, no doubt, to a certain extent, been supplemented by the early Bushmen, who are supposed to have used these rock-shelters, at least as occasional residences, with the result, that the overlying basalt or sandstone, protrudes over a large cavity, thus affording a cave-like shelter. The roof, and where practicable, the sides of these Bushman caves or rock-shelters are covered with usually crude, often coloured, and in some cases, comparatively artistic pictorial representations of the chase ; while in many cases efforts have been made, with no small degree of success, to depict individual natural history objects. These rock-shelters are quite similar, in their occurrence, the character of their drawings, and

the use to which they were put, to the rock shelters which so commonly occur in many parts of Australia, I have not heard of any of these Bushman caves in Natal having been examined further than with reference to the drawings, but there is no doubt that many important and interesting discoveries of the relics of these early people would be made, if systematic and intelligent investigations were carried out in the deposits, which so often have accumulated to a considerable thickness, over the original floor of the shelters.

Just over the Berg from Natal, in the Orange River Colony, large quantities of prehistoric stone implements have been found, occurring either as isolated specimens in the soils and subsoils, or, as in certain localities, in large numbers in circumstances similar to those in which the rudely chipped stone celts occur in the Pleistocene and Recent soils in the neighbourhood of Stellenbosch, Cape Colony, recently discovered by Mr. Peringuay, of the Capetown Museum. In many parts of Natal, Zululand, and Swaziland, rudely chipped prehistoric stone implements are of common occurrence, but few collections of these have been made, and so far as I know, no systematic study of them has yet been attempted by anyone. Lately some papers have appeared in the Anthropological Journal on stone implements collected by Mr. Ryan in Swaziland. That it is an interesting, and, from an antiquarian point of view, an important subject, there is no doubt; its chief interest lying in the insight, which the study of such relics of the past, gives, into the life history of the early native races of this part of South Africa.

In the descent from Harrismith to Ladysmith, about 2,000 feet, good sections occur of the rocks, intervening between the Upper Karoo Beds of the higher Drakensberg and the Ecca Series, which outcrops in the neighbourhood of Ladysmith. This district will, when it comes to be examined geologically, prove an interesting, important, and instructive area, for the elucidation of the succession of strata from the Ecca Series upwards. The area to the north of Ladysmith, between that town and the Dundee and Newcastle coal-field, will also prove of interest and value, from a stratigraphical point of view, in the working out of the relations between the coal-bearing series of the northern part of the Colony and the Ecca Coal-bearing Series of the coast. To the southward, in the neighbourhood of Estcourt, thin coal seams have been discovered in the Ecca Series. These have, to a certain extent, lately been prospected, but so far they have not been found to be of sufficient thickness or quality to be profitably worked. Many of the black shales are fossiliferous and contain similar plant remains to those occuring in the Ecca Coal-bearing Series of the north coast and St. Lucia coal-field, Zululand. They are chiefly various species of *Glossopteris* and *Phyllotheca*. Some good specimens of these plants, from near Estcourt, have been presented to the Natal Museum by Sir Albert Hime.

In passing through the Dundee and Newcastle coal-fields, I had a cursory look at some of the coal-mines and the strata among which the coal-seams occur. The latter consist chiefly of coarse friable sandstones and grits, with carbonaceous and sandy shales and coals, intruded by dykes and sills of volcanic rocks, usually basaltic in character. On any

extensive outcrop of these rocks, the individual beds (be they sandstones, shales, or coals) are seen to present in section a lenticular form, and never attain any great development latterly. This fact, together with the frequency of the occurrence of intrusive rocks, has a considerable bearing on the working and value of the individual coal-seams; limiting as they do the extent over which individual seams will be found of a payable nature. In other parts of the world, in the coal-fields of Europe, America, and Australia, the coal-bearing strata, from their analogous mode of deposition, have the same lenticular form, but on a vastly larger scale. On a particular horizon, a coal-seam is usually persistent over a wide area, and notwithstanding the occurrence of faults and intrusive rocks, it can be followed and identified as occurring on the same geological horizon, usually over a large portion of the coal-field. Its presence thus indicates, with probable certainty, at any given point, the position and probable extent of any other coal-seams which occur in the same series, either above or below it. This difference of lateral extent between the coal-measure strata of Natal and other countries is due to the fact that although the Karoo Formation was deposited over one immense basin, stretching from Kimberley, beyond the present coast line of Natal and from the Transvaal to the south coast of Cape Colony, the conditions under which the deposition of the various sediments took place, were of a different character to those which obtained in other countries. That is to say, that there seem to have been local areas only, over which certain deposits of a similar kind were deposited. Here in South Africa, the alternation of sediment was comparatively rapid and of a local character, and the length of time during which any one kind of sediment was being deposited was locally restricted. In the case of the foreign coal-fields mentioned above, each deposition of sediment was prolonged over a lengthened period of time and deposited in a generally uniform manner over the whole area. In such a coal-field, where the various beds have been uniformly and extensively deposited, it is a comparatively easy matter (given the time and the necessary assistance) to obtain, by geological survey, an accurate knowledge of the sequence of the beds of the series, the horizons on which coal-seams occur, their relations to each other and the probable extent of the area under which productive coal exists. But with regard to the northern coal-field, which forms one of Natal's chief industries, there is little known geologically, chiefly owing to the fact, that no attempt has yet been made at a systematic geological survey of the district. The result of this is that any attempts at new developments which are made to work new ground, either by private individuals or public companies, are generally handicapped by the utter want of knowledge, as to, even the character of the strata through which they will have to bore, let alone, the knowledge as to what coal-seams may be expected to be met with and at what depths they may occur. In many cases, the systems of intrusive volcanic rocks, which occur so frequently, cutting these strata in an exceedingly erratic manner, can be traced out with sufficient accuracy, so as to obviate the necessity of useless prospecting or working in their vicinity. Because of the facts above stated, it is all the

more important that a knowledge should be obtained, by geological survey, of the correlation of the beds, the vertical thickness of the coal-bearing series and the areas under which productive coal may probably be obtained.

The report by Mr. F. W. North, published by the Natal Government in 1881, contains a large amount of geological material in the form of natural sections and bores; but no attempts have been made to correlate the various coal-seams which are known to occur in different parts of the coal-fields. Such a result was utterly impossible in the short time occupied by Mr. North in his examination of the coal-fields of Natal.

In the records of the Department of Mines, there is a quantity of material which will be of use when a geological survey of the coal-measures is undertaken; and I hope, that, in the near future, the geological mapping of our coal-fields, will form one of the most useful and important pieces of work, that the geological survey will perform. In reference to this matter, I would remark that in the case of boring, especially among coal-bearing strata, it is most important and absolutely essential to the value of the cores, that they be examined by a competent authority, and that the various strata, passed through in the bore, be accurately named, so that, when published, the record may be reliable for future reference. Unless this be done, at least half the utility of the boring is lost. In fact, the cores should, in every case, be preserved and accurate statements as to the exact position of the bore holes be recorded. And, still further, in cases where fossiliferous strata are passed through in a bore, or where fragments of fossils are noticed in the core, no matter how fragmentary and apparently worthless they may appear to be, as specimens, they should be carefully preserved for palæontological examination. Fossil remains are such an important factor in aiding the geologist to determine the relative age, succession, and correlation of the strata, that, without their evidence, in many cases, it is most difficult, and often impossible, without the expenditure of a large amount of time, to work out the geology of a district by stratigraphical evidence alone, as it is so often, of such an imperfect kind. I cannot impress too strongly upon the Government the fact, that the chief utility of a bore is, not only, to obtain the purely local knowledge of the strata through which it passes, but to have that knowledge accurately delineated and recorded with all particulars, as to exact site, &c., so that the record will be available in the future, for comparison with other bores or sections in the neighbourhood or elsewhere.

As regards the palæontology of this coal-field little is known, as no systematic collections of the fossil remains, which occur so plentifully in the shales and sandstones, have been made. They are chiefly the remains of plants. One very characteristic form, which occurs plentifully in the Newcastle Coal Series is in the form of flattened stems, exhibiting, as Mr. Etheridge, to whom they were submitted, describes "indistinct traces of longitudinal sulcations but nodes are not pre-" "sent. It is quite impossible to hazard an opinion on the identification" "of these fragments. In all probability they are not the remains of a"

"Calamite." The specimens referred to above, were taken from the Newcastle Syndicate Collieries Company's Mine. Previous writers have referred the Dundee and Newcastle Coal-bearing Series to the Stormberg Beds of the Upper Karoo Formation, of the Eastern Provinces of the Old Colony. This correlation is, however, an important point which has yet to be worked out, as the evidence upon which the inference is based, is of a most fragmentary and unreliable kind.

In the beds around Weston, on the Mooi River, fossil remains of the bony skeletons of reptiles have been obtained, and the fossil remains of fish have been discovered in the rocks of the Biggarsberg; specimens of these latter occur in the collection of the Natal Society's Museum. In the same collection specimens of *Glossopteris*, &c., occur in the Ecca Shales of the Estcourt district; while fragmentary specimens of reptilian remains are present from Ennersdale, near the Little Bushman's river, and from Spitz Kop on the Little Tugela river.

Although the railways of the Colony are necessarily of a light kind, from the mountainous character of the country, the cuttings usually exhibit good geological sections of the strata. As the sedimentary rocks are generally horizontal or only slightly inclined, their occurrence and succession can be well seen, from the highest to the lowest. Between Highlands railway station, 4,953 feet above the sea level, and Pietermaritzburg, 2,218 feet, a good knowledge can be obtained of the descending series of beds, passing through the Ecca Shales to the Dwyka Conglomerate, which is very well marked in the neighbourhood of the Capital. A line drawn, in a generally north-~~easterly~~ and south-~~westerly~~ direction, some distance to the east of Cato Ridge railway station, would show the eastern limit of that great series of rocks, the Karoo Formation, including the Dwyka Conglomerate, the Ecca (~~Pietermaritzburg~~) Shales, the Stormberg Beds, and the Cave Sandstones; except for the outliers of Dwyka Conglomerate and Ecca Shales with coals, which locally fringe the coast line of Natal. Representatives of this Karoo Formation are thus seen to occupy a good deal more than the north-western half of the Colony, where our chief deposits of coal and iron exist. The eastern limit of the outcrop of this formation is traceable by the outcrop of the Dwyka Conglomerate, in an approximate line drawn from the junction of the Buffalo and Tugela rivers, past Greytown, Baynes' Drift, Thornville, Cato Ridge, a few miles east of Richmond, High Flats, and Harding, to near the mouth of St. John's river, on the south-east coast. Along this line, from Greytown to St. John's river, and again, along almost the entire coast line of Natal, the Ecca Shales and Dwyka Conglomerate form the chief rock outcrops, with those of the Palæozoic Sandstones and Metamorphic rocks between, as shown in the section (Pl. XIV.).

Typical sections of the Ecca Shales can be seen almost anywhere in the immediate neighbourhood of Pietermaritzburg. They are usually dark carbonaceous-looking shales, which have a spherical weathering, and finally break up into very fine debris. The upper portion of these shales consists of variously light-coloured shales and sandstones, with occasional thin impure coals. This portion of the series is well

developed on the north coast in the Country of Victoria, and probably the rocks containing thin coal-seams, near York, and to the west of Greytown, to the north of Pietermaritzburg, also belong to the same horizon. The lowermost beds of the Ecca Shales, where they pass into the Dwyka Conglomerate, have, to a very large extent the look and petrological characters of the matrix of the underlying Dwyka Conglomerate. In fact, both on the Durban road near Thornville and near Baynes' Drift on the Umgeni river, sections occur, which show the passage upwards, by easy gradations, from a strongly-marked glacial conglomerate to the fine-grained mudstones and carbonaceous shales of the Ecca Beds. Like all the overlying formations, they are much intruded by basaltic dykes and sills. This can be well seen on the Town Hill, particularly at the excavations made, where one of these volcanic sills is being quarried for Corporation purposes. The section in the quarry shows the Ecca Shales above and below, into which the volcanic sill has been intruded. This volcanic rock is a typical, medium-grained dolerite, consisting of triclinic felspar, augite and magnetite, with a considerable quantity of a light green material, which is mostly a decomposition product of the augite, although there are evidences of very minute olivines, showing the usual green decomposition cracks traversing them. The whole rock is an intimate crystalline mixture of, chiefly augite and triclinic felspar, and the whole structure would indicate a rock of a very durable character, the only weak point being the presence of the small quantities of green decomposition products.

The Ecca Shales in most places that I have examined them, in Natal, seem to be conformable with the underlying Dwyka Conglomerate, although, in mapping the Stanger district, I found that, locally, there was quite evidently slight unconformity. They are, undoubtedly, conformable with the overlying series which passes up into the Upper Karoo Formation. These shales have a persistent uniformity of character wherever they are known to occur, the black carbonaceous shales overlying the Dwyka followed by a series of grey shales and sandstones. These can be well seen in the sections on the railway, both in the neighbourhood of Pietermaritzburg and also on the north coast above the Tongaat river. An exactly similar series of shales occurs at Kimberley, overlying the Dwyka Conglomerate, and among which the diamondiferous deposits exist. The coal-bearing series of the north coast overlies this series of shales, but in the Transvaal, as for instance at Vereeniging, coal-seams occur as low down as the horizon of the glacial conglomerate. According to Mr. Dunn* these coals actually occur in the glacial conglomerate, the roof of the coal-seam being formed of that rock. Whenever the Ecca Shales are developed to any extent, very carbonaceous layers and thin coal-seams occur, associated with the upper portions of them. This occurs in the Estcourt, York, Greytown, and Tongaat districts.

So far as I have seen, both the black and the grey shales are entirely unfossiliferous, but immediately the sandstones of the coal

* Trans. S. African Phil. Soc. Vol. IX., Pt. I, p. 67.

measures begin, fossils become plentiful, and in the black shales associated with the coal-seams, fossil plants are of very common occurrence. These plants chiefly consist of numerous species of *Glossopteris,* while it is common to find thin layers of shale consisting of little else than the matted remains of *Phyllotheca.* On the north coast, where I have had an opportunity of examining the occurrence of coal in these beds, I have noted, that they are almost entirely composed of the foliage of these plants and the fragmentary remains of others that are indeterminable. There is also an entire absence of fireclays in connection with the coals, and at Morewood Cove, where the coal, at its outcrop on the sea-cliff, is 14 inches in thickness, it rests immediately on a fine-grained sandstone containing carbonaceous layers. No traces of root-marks were found penetrating this sandstone, so that it seems to me, that these coals have been formed of vegetation, transported from a distance, by the agency of running water, and deposited, in a fragmentary condition, in the shallow lakes, in which the coal-seams were formed.

As will be seen further on in Mr. Etheridge's report "On the Fossil Plants from the Coal-Measures of St. Lucia Bay Coal-field, Zululand," he concludes, from the palæontological evidence, that the coal-measures there, are of Permo-Carboniferous age. I have little doubt, from the stratigraphical evidence I possess, that the Zululand Coal-Measures can be correlated with the Ecca Coal-bearing Series of the north coast of Natal.

The Dwyka Conglomerate, wherever it is exposed, is always an unmistakable rock, as there is nothing else like it, at least, in South Africa. The boulder beds of the Talchir Formation of India, the boulder beds of Bacchus Marsh in Victoria, and of the Newcastle Coal-Measures of New South Wales, Australia, are deposits of similar origin Within the last few months a boulder bed of glacial origin has been discovered by Mr. A. Gibb Maitland, Government Geologist of Western Australia, associated with the Coal-Measures of that Colony. All these boulder beds, with the exception of the last mentioned, have been correlated, by means of the palæontological evidence obtained from their associated shales, as having been formed towards the end of the Carboniferous Period, while the overlying Ecca Shales are of Permian age. They possess local differences of character, but with undoubted evidences of a common glacial origin.

In Natal it has usually a blue, sometimes yellow, argillaceous matrix of a compact kind, in which are embedded pebbles and boulders of all sizes, from minute grains to blocks of many tons in weight. They are generally angular, sub-angular, and rounded, and consist of all kinds of durable rocks, chiefly, however, metamorphic, crystalline, and volcanic. Good sections of this rock can be seen almost anywhere along the coast belt, but the most extensive are those exposed in the quarries at Umgeni Bridge, near Durban. In most cases, the pebbles and boulders are foreign to the district in which they are now present in the conglomerate, although this is not always the case. I have noticed boulders of crystalline limestone in the Dwyka exposed on the beach near Park Rynie, on the south coast, which could be identified as being similar to the limestone of Port Shepstone. In the districts where the

Dwyka rests immediately on granites or sandstones, as in the neighbourhood of Krantz Kop, near Greytown, boulders and pebbles of these rocks are quite readily recognised as of local origin.

In many localities in this Colony, where the Dwyka Conglomerate has recently been removed by denudation, thereby exposing surfaces of the underlying rocks, these latter are found frequently to exhibit beautifully-polished and well-marked striated rock-surfaces, which could only have been produced by the agency of ice. Such glaciated surfaces are of frequent occurrence in the Stanger district, Victoria County, and will be noted in my report on that district. In the neighbourhood of Krantz Kop, Umvoti County, where the Dwyka Conglomerate thins out on the horizontally-bedded Palæozoic Sandstones, and overlies the Metamorphic Gneisses and Schists, it is a common occurrence to come across boulders, usually of considerable size, which exhibit a smoothly-polished or striated surface on one end or on one side, which has been ground flat by its contact with the underlying bed-rock, as the whole mass of ice, with its enclosed rock-debris was moved over its surface. In most of the other localities in which I have seen outcrops of Dwyka Conglomerate, striated pebbles and boulders are of rare occurrence.

The matrix, on decomposition, usually breaks up into small scales, and the rock, often over large areas, exhibits this somewhat parallel scaling, to such an extent, that it would seem as if its precursor had been original indistinct stratification. It can neither be due to shearing nor superinduced cleavage, because it is never seen to pass into, let alone through, the smallest pebbles, while the rock shows no evidences of metamorphic action. This scaling, which is usually very noticeable where the decomposition has been caused by sea water, on the coast, can be seen in many localities, to have a general direction parallel to the bedding of the shales overlying the Dwyka. In the undecomposed rock, the matrix is exceedingly compact, and shows no evidences of the presence of stratification.

In the Umzinto district, a series of blue, fine-grained, fissile shales occur, associated with the Dwyka Conglomerate, which have been used as roofing slates, and in the towns, as paving stones. Slates of a similar character occur, also associated with the Dwyka Conglomerate, in Zululand, about five miles to the north of the Mahlabatini Magistracy, and show frequent concretions of pyrites, often of large size. They are not, however, to be compared for utility, with the roofing slates of Europe or America, which are of a different age and belong to a much older formation. The latter have usually undergone metamorphism, and their fissility is due to superinduced cleavage, while the so-called slates of Natal are really shales, which split along the original lines of bedding, and are not nearly so fissile. They are fairly durable, wear well, but unevenly, as paving stones, but are rather brittle.

The peculiar character of this deposit has occasioned much controversy among geologists. It is now, however, generally accepted that, during the formation of the Dwyka Conglomerate, the climatic conditions were glacial, and in many localities the detritus of which it

was formed, particularly the large boulders and coarser materials, were transported for long distances, from some ice-clad land surface, by the agency of floating ice. Upon the melting of this ice, the boulders and rock-debris were released and sank to the bottom, to form the deposit now known as the Dwyka Conglomerate. There are also, however, unmistakable proofs, that in some parts of Cape Colony, the Dwyka Conglomerate represents now, what originally were, ground moraines. These had been formed on land, in connection with the ice-sheet, from which were calved the icebergs, which transported the rock-debris now forming the Dwyka Conglomerate above mentioned.

Later on in this report mention is made of the explanation which my friend, Professor Corstorphine, of Capetown, has brought forward, as to the difference of origin between the northern and southern Dwyka Conglomerate of Cape Colony.

In the belt of country lying between the uplands and the coastal outcrops of the Dwyka Conglomerate, and stretching from the Tugela to the St. John's river, a characteristic feature of the scenery is the frequent occurrence of plateaux of horizontally-bedded sandstones and isolated table-topped mountains, the upper parts of which are formed of precipitous sandstone cliffs. The Dwyka Conglomerate rests unconformably on these sandstones, which have been called by the late Dr. Sutherland, Table Mountain Sandstones. [By Mr. E. J. Dunn they have been correlated with the Witteberg or Zuurberg Series of the Old Colony.] They are here usually thick, false-bedded sandstones, with grits and conglomerates, rarely quartzitic, and seldom with any thickness of shales among them, other than mere shaly partings. A characteristic section can be seen in the quarry, close to the railway, some miles to the west of Pinetown. Petrologically, they are very unlike the quartzites and grits of the Table Mountain Sandstones of Cape Colony. They are almost entirely unfossiliferous. The only instance of the presence of fossil remains is recorded by Mr. C. L. Griesbach. In the neighbourhood of Krantz Kop, near Greytown, he discovered indistinct traces of indeterminable fossil shells, in shales associated with these sandstones. Although I have visited this district, I was unsuccessful in locating the position from which Mr. Griesbach obtained the fossils. So far as I have noticed these sandstones, in the various parts of the Colony in which I have yet been, I have never seen them in immediate association with any rocks other than the Dwyka Conglomerate and the Metamorphic Granites, Gneisses, and Schists. The utter want of palæontological and stratigraphical evidence makes it, as yet, impossible to hazard an opinion as to the correlation and age of this sandstone series. In some localities it contains auriferous quartz veins, but although individual samples have been very rich in gold, no instance has yet occurred where these reefs are payable. As a rule, they are in the form of joint veins, which, in a bedded rock of this kind, rarely attain any great development vertically. Large quartz reefs do occur sometimes, but in no instance has even a trace of gold been found in them. The basement beds are usually very coarse conglomerates, and as they rest upon, and have been derived from the degradation of the

metamorphic and granitic rocks, they are sometimes auriferous. Occasionally, from the large amount of felspar which they have derived from the denudation of the underlying metamorphic rocks, they form, locally, through the decomposition of the felspar, beds of impure kaolin.

Like the other formations, this is much intruded by volcanic rocks. In the Clairmont bore, some miles to the west of Durban, over a hundred feet of a heavy doleritic rock was passed through; this volcanic rock being intrusive in the Palæozoic Sandstones.

A short distance to the east of Inchanga on the railway line, these Palæozoic Sandstones give place, to a grey porphyritic granite, against the denuded surfaces of which the sandstones abut. This belt of granite outcrops in the railway sections as far as Botha's Hill station, when the horizontally-bedded Palæozoic Sandstones again overlie it and persist, with a slight dip towards the sea, as far east as Malvern station, where the Dwyka Conglomerate again outcrops. In some districts schists and gneisses are associated with the granite, and the whole forms a narrow belt, stretching through the Colony from the Mapumulu, district, on the Tugela river, through Noodsberg, Inchanga, Mid-Illovo, to near the mouth of the Umtamvuma river, in a direction approximately parallel to the outcrop of the Dwyka Conglomerate. In the Umzinto district and in the lower parts of the Buffalo and Tugela river valleys, a series of metamorphic schists, gneisses, and limestones occur, associated with granite. In the latter localities they form the fundamental rocks of the district, upon which the Palæozoic Sandstones, and in some instances —as in the neighbourhood of Krantzkop—the Dwyka Conglomerate, have been laid down unconformably. They chiefly consist of hornblendic and micaceous gneisses and schists, with occasional heavy, basic, hornblendic, crystalline rocks. Wherever I have had an opportunity of seeing them, their cleavage planes are more or less persistent at a high angle. Similar gneisses and schists occur in the southern part of Zululand, under the same geological conditions as those of Natal, but here the axial granite shows a considerable amount of shearing. These granites, gneisses and schists form the oldest series of rocks in this part of South Africa, and that portion of the country where they are exposed by denudation defines, in a broad way, the area of the Colony in which minerals of economic value, other than coal and iron, will be found, if they exist anywhere, in payable quantities. To the west of Umzinto, a considerable amount of prospecting work has been done in the neighbourhood of Dumisa. Here, thin leaders of quartz have been tunnelled upon, in one case to over 500 feet. Much stoping has been done and a considerable bulk of material was put through the batteries. Results were fairly promising for a time, but ultimately they had all to be abandoned. In all cases, the gold was chiefly confined to the leaders of quartz, although much of the crushed country rock was put through with the quartz, and probably carried a certain percentage of secondarily deposited gold.

Of formations, newer than the Upper Karoo, there are few repre-

sentatives either in Natal or Zululand, and, when present, they are of a purely local character. So far as is known, the fossiliferous series of the Uitenhage district of Cape Colony is not present in any part of Natal. On the south-east coast, however, at the mouths of the Umtamvuma and Impenyati rivers, local patches of Mesozoic Strata, referable to the Upper-Cretaceous Formation, occur. These beds have proved to be very fossiliferous, and have been separated into the following divisions; each set of beds being characterised by a distinct series of fossil remains. These divisions are as follows:—

(1) Zone of *Ammonites Gardeni.*
(2) Gasteropoda Bed.
(3) Ammonite Bed.
(4) *Trigonia* Bed.
(5) Sandstone with fossil wood, &c.

Altogether nearly 50 species of fossil Invertebrates have been recorded from these deposits, including 8 Cephalopoda, 16 Gasteropoda, 1 Scaphopod, and 19 Lamellibranchiata, with a few fragmentary remains of Vertebrates, chiefly Reptilian and Amphibian. More than half of these have been described for the first time, from the Upper Cretaceous deposits of south-east Natal. Palæontologically they bear a close resemblance to the fossil forms obtained from the Upper Cretaceous Series of Southern India.

A list of the fossils identified from these deposits is given further on in this report.

By the occurrence of *Alectryonia ungulata* identified by Mr. R. B. Newton, the presence of Upper Cretaceous deposits, has been proved in the district of Sofala, north of Delagoa Bay. A limited development of similar rocks also occurs on the coastal area of Zululand. These latter, with their fossils, will be described later.

So far as is known, no sedimentary deposits of Tertiary age, exist in Natal; although it is quite within the range of possibility that some of the deposits, exposed on the littoral, of the northern portion of Zululand, may prove to be referable to that age. Further to the North, in the valley of the Busi river in Gazaland, nummulitic limestones occur, which are of Lower Tertiary age; while, on the western coast of the island of Madagascar, deposits of Tertiary age overlie the Cretaceous rocks, which again rest upon the fossiliferous Jurassic rocks of the interior.

Resting upon the Ecca Coal-bearing Series and forming the ridge which separates Durban harbour from the Indian Ocean, are a series of false bedded calcareous sandstones. At Wentworth, further to the south, these calcareous rocks again crop out on the sea-shore, and I believe also at Isipingo. So far as I have had an opportunity of investigating them they seem to be unfossiliferous and rest unconformably on the Ecca Beds below. Traces of them occur in various places immediately to the west of the harbour. The presence of these rocks which now form the Bluff, has no doubt been a considerable factor in the formation of Durban bay and harbour. At present, there is nothing to indicate to

what formation this series of calcareous sandstones belong. So little is known of the Tertiary and Upper Secondary Formations on the east coast of Africa, that it is impossible to say, without fossil evidence, whether they represent the later rocks or a portion of the earlier. They are certainly separated from the Ecca Series on which they rest, by a well marked unconformity.

Of Pleistocene and Recent deposits the coastal area supplies us with many examples, in the form of raised beaches, sand dunes, &c., while the alluvial river flats and the loose surface material covering the inlands, derived from the weathering and degradation of the various rock formations, furnish the Colony with its soils of rich and varied character, which have gained for it the sobriquet of the Garden Colony. There is no doubt that in almost every district in Natal, where the soils are of a particularly productive character, one of the chief reasons for their richness, is to be found in the fact, of the almost universal distribution of intrusive volcanic rocks of a heavy basic character, whose degradation, by surface denuding agents, has resulted in enriching the otherwise poor soils, that would have been produced by the disintegration of those rocks (shales, conglomerates and sandstones) which form by far the greater portion of the surface geology of the Colony. This is typically exemplified in the coastal area, where, in a large number of instances, the areas under tea and sugar cultivation, invariably possess a soil, which has been largely derived from the degradation of local intrusions of volcanic rocks.

As regards the volcanic rocks of Natal and Zululand, nothing can yet be said, but in a very general way, as no attention has previously been given to them. A few general observations may, however, be made here, chiefly in reference to the occurrence of these rocks. The heavy basic rocks are chiefly basaltic in character and are almost universal in their occurrence, as they crop out in nearly every district They are usually in the form of intrusive sills and dykes, although it is probable that they occasionally occur as contemporaneous lava sheets. On the Umfolosi river in Zululand a considerable area of country is occupied by basaltic rocks, which may probably prove to be of the latter character. It is often difficult, from the unsatisfactory outcrop of these rocks to tell whether the rock is in the form of a dyke or a sill, the latter being, however, the more common and more easily recognised. A good example of the basaltic dyke occurs at and forms the bulk of the Inhluzane mountain about 30 miles west of Pietermaritzburg. Many other varieties of basic rocks occur besides basalts, but until time offers for the investigation of these, little can be said concerning them, although there are many interesting and peculiar points in their petrography.

Of Acidic rocks outside the granites, so called felsites are said to occur among the coal-bearing rocks of the coast and also are reported from the north of the Colony; while in Northern Zululand a Rhyolitic lava occurs, forming the Lebomo Range. This is an extremely interesting rock and presents many peculiar features, which I hope to describe at some future time.

HISTORICAL SKETCH

OF

NATAL GEOLOGY.

HISTORICAL SKETCH OF NATAL GEOLOGY.

It will not, I think, be out of place, in the first report issued by the Geological Survey of Natal and Zululand, to give a brief historical sketch (accompanied by a bibliography) of what has previously been written on the geology of the Eastern Colony. The large area of Natal, which is occupied by an eastern extension of the great Karoo Formation of the Old Colony and the Orange River Colony, has doubtless had a limiting effect upon the production of papers dealing exclusively with Natal Geology. This has been owing to the necessarily, general similarity of the strata, to those of the geologically better-known portions of South Africa; and further, to the fact, that, what has been done in the working out of the larger geological problems, connected with this formation—chief among which is its coal-producing capabilities—has so far, almost entirely, been worked out, from the larger developments of these rocks, occurring in Cape Colony; that Colony having been much more accessible in the early days. With regard to the Province of Zululand, very little authentic geological information has been recorded, although a good deal of prospecting has been done in certain parts of it, and for a long number of years, shooting parties have traversed the country in all directions. It is to be regretted that so few people, who have the advantages of living and travelling in such little known countries, take the slightest interest in observing and recording curious facts referring to the country, its inhabitants or its flora and fauna.

One of the earliest published notices, referring to the geology of Natal and Zululand, occurs in a paper by Captain R. J. Garden, where he records the discovery, made by Mr. H. F. Fynn, as far back as 1824, of the fossiliferous Cretaceous rocks, occurring at the mouths of the Umtafooma (Umtamvooma), Impenyati and Umtata rivers, on the south-east coast of Natal and the neighbouring Colony. Accompanying this paper, published in 1855, a detailed description is given, by Mr. W. H. Baily (of the Geological Survey of Great Britain), of the fossils collected by Captain Garden from the Cretaceous deposits of the above mentioned localities. From his examination of these fossils, Mr. Baily classed the beds, as belonging to the Upper Cretaceous, and he further states, that his description of the Natal fossils "has been drawn up on the plan of" "Prof. Forbes' able Report on the Fossil Invertebrata from Southern" "India, to which collection of fossils the series here described bears" "a close affinity, as also to the fossils from the Greensand of Black-" "down in our own country and the Craie Chloritée of France."

In the same year, an important paper on the Geology of Natal was read before the Geological Society of London, by the late Dr. P. C.

Towards the end of the decade the more important papers were by Mr. H. F. Blanford and Mr. E. J. Dunn, late Government Geologist of Cape Colony. In both of these, efforts are made to establish a correlation between the coal-bearing series of northern Natal (Stormberg Beds of Cape Colony?) with the plant-bearing series of India and the Permo-Carboniferous coal-fields of Australia and New Zealand. In a paper by Mr. J. F. Whiteaves, "On the Fossils of the Cretaceous Rocks of" "Vancouver and Adjacent Islands in the Strait of Georgia," mention is made of the fact, that during Upper Cretaceous times the form *Ammonites Gardeni,* Baily, originally described from the Cretaceous rocks of the south-east coast of Natal, had a very wide geographical range, occurring as it does, in the Upper Cretaceous rocks of Vancouver Island, the Trichinopoly Series of Southern India, and in the Cretaceous rocks of Australia and Natal.

In the early eighties Mr. F. H. North made a report for the Natal Government, on the Natal coal-fields, in which he records a large amount of geological data in the form of natural and boring sections, obtained from the areas of coal-bearing rocks in the Klip River district, Umvoti County, and on the north coast. Another paper of great importance geologically was read before the British Association at Montreal, Canada, in 1884, by Prof. T. R. Jones. In dealing with the general geology of South Africa, he touches incidentally on some points of Natal geology, and gives a table showing the various South African sedimentary formations with their divisions, so far as they were known at that date. Again in 1886, the same author, in an article in the Mining Journal dealing with the coal deposits of South Africa, gives a short account of the occurrence of coal in Natal, and correlates the Dundee and Newcastle coal-measures with the Stormberg beds of the Cape and Orange River Colony. Another important report was published in the same year by Mr. E. J. Dunn, in which he suggests that there is great probability of the occurrence of coal-seams about the horizon of the Ecca Shales; and that as there is good reason to believe, that these rocks pass underneath the greater part of South Africa, the existence of the Ecca Coals should be proved, by deep bores, in various localities in the Karoo. He also refers to the presence of coal among the Ecca Shales at Compensation Flats in this Colony, and further states that "probably boring near Ladysmith Flats, where these same rocks" "underlie, would bring to light thicker seams at a lower horizon than" "the Newcastle and Dundee coal-seams." He also compares the Stormberg Coal-Measures with the Upper Coal-Measures of Queensland in Australia, and would infer from the fact, that a lower coal-series occurs at Newcastle in New South Wales, Australia, it is reasonable to suppose that in Cape Colony the analogue holds good, and that we might reasonably expect to find a lower coal-series on the horizon of the Ecca Shales.

During the last decade a considerable number of papers occur from individual geologists, while a large amount of material has been collected together in the official publications of the Mines Department in the form of bores, &c. In a paper by Mr. F. Rutley, dealing with the petrology

of the siliceous replacements of dolomitic limestones, a case is mentioned of a gold-bearing quartzite from Nondweni, Zululand, which exhibits evidences of this replacement. His conclusions are, that the gold originally occurred in a bed of limestone, which has been dissolved by percolating water and replaced by quartzite. He says: "We have," "then, in this rock a case in which a quartzite of comparatively coarse" "micro-texture has originated as a siliceous replacement of a limestone," "just as I believe the fine grained Onachita stone and the still finer" "Arkansas stone are the siliceous replacements of dolomite or of" "dolomitic limestones."

In 1896 two papers occur, by Mr. R. Bullen Newton, dealing with the occurrence of Upper Cretaceous and Lower Tertiary rocks in South-eastern Africa. In the paper read before the Conchological Society the author gives a *resumé* of all that has been written and is known, with regard to the Cretaceous deposits of the South-east Coast. In the same year a paper occurs by Mr. D. Draper "On the Dwyka Conglomerate," in which he disputes the glacial origin of that deposit and instances some parts of Zululand, which suggest to him a volcanic origin for it. Another paper, on the Dwyka Conglomerate, is by Dr. Molengraaff, in which he furnishes undoubted evidence of the glacial origin of the formation, instancing numbers of cases in the Vryheid district, on the western borders of Zululand, where the underlying quartzites, on which the Dwyka rests unconformably, are polished and striated in such a manner, that they could only have been produced by moving ice. Since this date, much proof has been forthcoming in support of the glacial origin of the Dwyka Conglomerate; so much so, that it is now almost universally accepted by geologists.

It will be seen from this short *resumé*, of the more important papers, dealing with the geology of Natal and Zululand, that, not only, are there many interesting and important geological subjects, many of them possessing more than a local interest, to be investigated, in working out the geology of Natal and Zululand, but there are geological subjects, which are of vital importance to the economics of the Colony and therefore to the well-being of the Colonist.

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BIBLIOGRAPHY OF NATAL AND ZULULAND GEOLOGY.

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REPORT

ON A

RECONNAISSANCE GEOLOGICAL SURVEY

OF THE

EASTERN HALF OF ZULULAND,

WITH A

GEOLOGICAL SKETCH MAP OF THE COUNTRY TRAVERSED.

REPORT ON A RECONNAISSANCE GEOLOGICAL SURVEY OF THE EASTERN HALF OF ZULULAND, WITH A GEOLOGICAL SKETCH MAP OF THE COUNTRY TRAVERSED.

INTRODUCTION.

Up to the present time, few papers or reports, have been written, dealing with the Geology of Zululand. They are almost entirely confined to the official, annual reports, of the Commissioner of Mines for the Province, and naturally deal with purely mining matters, but contain, scattered throughout them, a good deal of geological information. These reports were published by the Natal Government, under the direction of Mr. J. J. Garrard, then Commissioner of Mines for Zululand, from 1894 to 1897. Since that time, the official mining reports from Zululand, have been incorporated with the annual report of the Commissioner of Mines for Natal.

Outside these official sources, only a few incidental notices occur, referring to points of Zululand geology. Mr. C. L. Griesbach* in describing the Cretaceous deposits of Natal, mentions a locality in Zululand "in the bed of a small stream running into St. Lucia Bay" where Cretaceous rocks are exposed. A short notice occurs, in Nature, by Mr. C. E. de Rance,† on the "Geology of Natal and Zululand," while mention is made, by Mr. D. Draper‡ of the thinning out of the Karoo Formation, northwards, in Zululand and Swaziland. In another paper on tbe Dwyka Conglomerate, the same author refers to some sections, on the Umkuzi river and at Nondweni, from which he concludes, that these rocks are of volcanic origin. In the Journal of the Geological Society of London, Mr. F. Rutley§ describes the structure of some rocks from Nondweni, as examples of the replacement of limestone by silica, in a calcareous gold-bearing quartzite, from that place. So far as I am aware, these few references to Zululand geology are all that exist, and show, what a small amount of geological information has been recorded, and how little is really known, with reference to the geology of the Province.

Considerable efforts have been made to prospect, in a somewhat desultory way, certain portions of Zululand for gold, coal, and other

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*Quart. Journ. Geol. Soc., London. Vol. xxvii., pt. 1. 1871.
†Nature Vol. xix., pp. 467. 1879.
‡Quart. Journ. Geol. Soc., London. Vol. I., pp. 548. 1894.
§Quart. Journ. Geol. Soc., London. Vol. I., pp. 377. 1894.

minerals of economic value. So far, the results have not been of a very encouraging nature, but to a certain extent, this has been largely due to the unskilfulness of the majority of the prospectors and the slipshod methods of prospecting which they employed. The area prospected, for the ores of the heavier metals, such as gold, copper, &c. occupies the western portion of the country bordering the Transvaal. This area, I was prevented, by the outbreak of hostilities, with the Dutch Republics, from including in the reconnaissance survey of 1899, but I hope, at an early date, to be able to give my attention to this part of the Province.

With reference to the area occupied by coal-bearing rocks, I was enabled to make a cursory examination of a considerable portion of it. No real developments of these coal-fields have, as yet, been attempted, chiefly, I believe, because of the anthracitic nature of many of the coal-seams, where they have been struck by bore or shaft, together with the impossibility of sea carriage, and the expense of transport to the nearest point, on the Natal railway system. The question of transport to the railway, however, will shortly be a preventative no longer, as the southern portion of the Zululand railway, is now in course of construction, and is in a fair way to be completed within the next few years. As regards the areas of coal-bearing rocks, which occur near the coast, the railway will tap them all, as there is no coal area further north than St. Lucia Coal-field, at least, in the coastal district. Along the immediate coast line, however, there occur deposits of lignite, which are probably associated with the newer Secondary or Tertiary rocks. The lignites often attain a great thickness, but as a fuel, they would probably be much inferior to even the poorer of the anthracitic coals, which occur among the older coal-bearing strata.

During the latter half of 1899, I proceeded to make a reconnaissance geological survey of the Province of Zululand. The route taken was from Bond's Drift to Eshowe, and from thence, up the coast road, as far as the lower portion of the Lebombo range, returning by the Makowe hills and the western road, which skirts the Transvaal border, to Melmoth and Eshowe. By following this route, I practically covered the eastern half of Zululand, between the Transvaal border and tbe sea, as far north as the southern portion of the Lebombo range. Wherever it was possible, and wherever anything of geological interest or importance demanded, traverses were made, off the main route, so that as much of the country could be examined as possible. In this way, a rapid survey was made, and a geological sketch map of the country was prepared, in which, the general areas occupied by the various formations, are laid down, together with such other geological information as was obtainable. By far the larger portion, of this part of Zululand, consists of rocks usually associated with the coal-bearing strata, together with their intruded and interbedded volcanic rocks, which are exposed over considerable areas, both on the foothills and on the high plateaux. A considerable area to the east of Eshowe, embracing the Engoye Mountains, is occupied by metamorphic rocks, consisting of granites, gneisses and schists; while in the neighbourhood of the coast, conglomerates, sandstones, marls and lignites, crop

out, from under the Pleistocene and Recent sands. They are very fossiliferous and belong chiefly to the Cretaceous period. It is possible that some representatives of the Tertiary period, may be discovered, along this coastal area. These formations will be dealt with in a more comprehensive manner below.

TOPOGRAPHY.

The topographical features of the province of Zululand may be separated into two distinct and well marked divisions:—The Littoral, and the Uplands or Highlands.

The littoral of Zululand varies much in width from about four miles, at the Umlalaas Magistracy, to over twenty miles, in the neighbourhood of False Bay, St. Lucia Lake. In general characters, it is flat or gently undulating, bounded on the west, by the rising foothills of the Uplands and skirted on the east, by the sand-dunes, which separate it from the sea. In places, where the depth of sand has been tested, during boring operations, it has been proved to be over ninety feet deep, but probably, in many localities, it is much more. Most of the surface sands have been blown into their present position, but underneath they show distinct stratification and often false-bedding, indicating that they had been deposited by the agency of water, most probably in lakes and lagoons. In many cases, sandy ridges still exist, standing out on this flat expanse of wind-blown sand, showing, when seen in section, such stratification as is mentioned above. Such a ridge occurs, running north and south, below the coast-drift of the Umhlatuzi river, and presenting, like so many of the existing sand-dunes of the coast, that characteristic chocolate colour, which is due to the ferruginous colouring matter in the matrix, and coating the sand grains, and is very often derived from the degradation of neighbouring volcanic rocks.

Much of the littoral is occupied by impassable, marshy areas and often impenetrable scrub. It is also studded with innumerable brackish and salt water lakes, lagoons and pans, of all sizes, from small mud-holes up to St. Lucia Lake, whose surface area, is about one hundred square miles. As a rule, the water in the smaller pans and lagoons is intensely salt; in fact, the position of the former is only recognised, in very dry weather, by the deposit of salt, left by the evaporated water. In many places springs rise to the surface, through the sands, supersaturated with salt, to such an extent, that on overflowing at the surface, evaporation takes place and layers of salt are deposited, for some distance round the orifice of exit. This salt is collected by the natives and used in lieu of the ordinary superior article of commerce. Most of this area consists of open country, there being nothing approaching a forest, in any part of it. In many localities, however, large tracts are sparsely covered with thorns, which rarely grow to any height and so widely apart, that there is not often any difficulty in riding through them. Of course, in many of the permanently running creeks, especially in the undulating portions of this area, where they have eroded steep and sometimes deep gullies, the latter are usually clothed with dense timber, of considerable size, and

thick thorny undergrowth. In the northern part of the Province, a peculiar aspect is given to the landscape, by the presence, in many localities, chiefly in the creek valleys, of a species of tree growing to a considerable height and in considerable numbers, whose stems and branches are of a light yellowish green colour, and which is locally known as the fever tree. Further north, however, on the littoral, between the Lebombo Range and the coast, as far up as Portuguese Territory, an india rubber producing plant grows plentifully. It seems surprising, that nothing has ever been done to increase the cultivation of this plant, the commercial product of which. is so much used in the arts and manufactures, and which has, within late years, become so scarce, because of the enormous increase in the demand for it, that prices have gone up accordingly. There is no doubt, that, if all reports be true, a large and important industry is awaiting development.

The sand dunes, immediately to the landward of high-water mark, are very persistent, along the whole coast-line, except where they are broken through, by the embochure of a river or the outlet of a lagoon. They vary greatly in height, sometimes attaining an elevation of over four hundred feet. Towards the sea they are usually flanked, by a strip, more or less wide, of dense, low, prickly, gnarl-branched, uncompromising scrub, through which it is almost impossible to force one's way. In most cases, they are covered, to their summits, with vegetation of some sort or another, but often, large areas of them are kept in section by the wind, and exhibit the general characters of wind-blown sand-dunes. When sections are exposed on their coastal aspects, it is no uncommon thing to see exposures of shelly deposits, extending in a lateral direction through the dune, and forming a lenticular deposit, often of considerable extent, both laterally and vertically. In portions of these deposits, lenticular patches of burnt ashes and shells occur, and occasionally bones of small deer and fish are to be found, together with broken pottery and rudely chipped stone implements. Such deposits are analogous to the kitchen-middens of prehistoric times, which are found on the coasts and raised beaches of Europe, America and Australia. At the present time, such deposits are being formed by the natives on the shore, where they, chiefly the women, periodically go to regale themselves on shell-fish, usually the mussel. Their method of procedure, after securing the requisite quantity of shell-fish, from the neighbouring rocks, exposed at low water, is to lay the individual shells on the sand, in a single layer, and resting against each other, usually in a spot which they had used at a previous time, and cover the layer of shells with a heap of light brushwood, to which they set fire. By the time that it has burnt itself out, the shell-fish are sufficiently scorched to allow of the shells being easily opened, and cooked enough for their taste. In the older deposits mentioned above, the oyster is of common occurrence, but at the present day, it is rarely met with, among the shell-fish used by the native.

The actual coast-line, nearly as far north as the mouth of the Umfolosi river, presents at intervals, more or less of a rocky character, although the rocks never assume the form of bluffs or cliffs of any height. As a rule, where they are exposed, they are only visible

between tide marks. Further to the north, rock outcrops become scarcer and scarcer, and only at wide intervals is there anything resembling a headland. This is, however, probably accounted for, by the fact, that on the southern part of the coast, the rocks underlying the Recent sandy littoral deposits, consist of the coal-bearing series with their associated volcanic rocks, which are usually of considerable hardness, and therefore resist denudation, while further north, as near Sordwana Point, Lake Sibayi, and the littoral at St. Lucia Lake, the underlying strata consist of such easily degraded rocks as limestones, friable sandstones, and marls belonging to more recent formations.

Much of the littoral area is thickly populated with natives, whose kraals are frequently seen in large clumps, surrounded by their cultivation patches. As a rule, the soil is sandy and poor, while in the neighbourhood of the rivers, lagoons, and small creeks, it is often very boggy and therefore useless for cultivation; but, as shown by the local collections of kraals in favourable spots, the soils in isolated places, are of fairly good quality, in fact, in such places near the coast mealies, &c. can be grown the whole year round.

Taken as a whole the coast of Zululand possesses no natural harbours. and, as is shown by the large number of wrecks which are present, at intervals, in all stages of breaking up, it is of a most dangerous character to shipping. Although there are numbers of large rivers, which debouch on to the littoral of this coast as permanently strong-flowing streams, there is in all cases, a bar of sand thrown up by the sea across their mouths. These sandy bars dam back the river water, until, often for miles inland from the mouths, it forms deep and often broad waterways, which, but for the presence of the bars would have formed splendid harbours and waterways for small craft. In many instances, larger lagoons intervene between the river and its exit into the ocean, but in these cases also, a similar and unfortunate sand bar exists. The two primary causes for this state of matters on the Zululand coast (as on the Natal coast) are, first, that there is distinct geological evidence, along these coasts, of the fact, that, since Tertiary times at least, the coast-line of South-east Africa has been slowly rising and becoming dry land. In fact, there is no doubt, that the greater part of the country, to which I have alluded as the littoral, represents now, as land, what was, in later Mesozoic times part of the coastal sea-floor. This is proved by the occurrence of marine beds of Upper Cretaceous age, which outcrop in various places on the littoral, from the foot-hills to the present sea-coast. It is even possible, that when this part of the Province comes to be thoroughly examined geologically, some representatives of the Tertiary Formation may be found to exist overlying these Cretaceous beds, as they do on the west coast of Madagascar. In consequence of this slow elevation of the littoral, the beds of the rivers, near their mouths, were also raised, thus causing a diminution in the rapidity of flow in the rivers, necessarily producing less erosion of their channels, with the result, that, aided by the damming back of the river waters, at their mouths, by the presence of the bars, reaches, waterways and lagoons were formed behind the sand bars at their mouths. The second

cause, is that which produces the damming back of the water in the mouth of the rivers, by forming the sand bars. This is due to a warm ocean current which, passing southward, through the Mozambique channel unites at the southern end of the island of Madagascar with the Madagascar current, which travels down the eastern coast of the island and the two uniting, form together what is known further down the coast of Africa as the Agulhas current. These permanent ocean currents, which set in along our coasts with so tremendous and persistent a force, have a very large share in the formation of their physical features. Their effect, is to produce a more or less straight coast line, with few indentations, headlands or bays of any importance. It is only in favoured localities, such as Delagoa Bay and Durban Bay where the local configuration of the country, in their immediate vicinities, has allowed of the formation of a bay at all, and these two, are very different, as regards their natural capabilities for harbour purposes. In the one case, the Bay is protected by a natural semi-circling breakwater, disposed in such a way, and capable of resisting the denuding action of the waves, that, instead of allowing of the blocking up of the mouths of the various rivers which debouch into the Bay, with sand banks, the effect of the current is to keep perpetually cleaning it out. With regard to Durban Bay, although it is quite open to the ocean great difficulty is experienced in keeping the entrance to the harbour free from the accumulation of sand.

The Uplands.

There is usually an abrupt line of demarcation, between the littoral and the uplands of Zululand. Between the Tugela river and Eshowe, however, a stretch of undulating country intervenes, but everywhere to the north, the country rises rather suddenly from the coastal plains. This elevated country is chiefly formed of coal-bearing and volcanic rocks, lying more or less horizontally, or with a slight dip eastward. Around Melmoth, to the east of Eshowe and to the north of Hlabisa metamorphic granites, gneisses and schists occur; while large tracts of the uplands are covered by basaltic outcrops, which sometimes represent contemporaneous lava flows but more commonly, sills and dykes, which have been intruded among the coal-bearing strata.

The principal rivers flow eastward, to the coast, where some of them, like the Umhlatuzi, passes into a large lagoon before entering the sea. During their course eastward, they and their tributaries have denuded the coal-bearing strata of the Uplands to great depths, and have formed extensive valleys, which sometimes assume the form of tremendous gorges, enclosed by precipitous cliffs, where good sections of the coal-bearing rocks are exposed. These will, no doubt, prove of great value, when a systematic geological survey of the coal-measures is undertaken. A line of fault probably exists, between the Metamorphic rocks and the coal-measures of the Intambanana coal-field, from near Eshowe, to the Imbabe river. Isolated areas of the uplands are heavily timbered and large tracts are covered with thorns, but as a rule, the country is open and affords splendid pasturage. The southern

portion of the Lebombo Range rises abruptly from the flat littoral on the east and on the west from an equally level plain. It is formed of a very siliceous rhyolitic rock and its surface always presents an exceedingly rough and rugged aspect. It is of the most barren description, and its rock-strewn surface has been cut into deep, precipitous valleys. On the plains to the west and south of the Lebombo range, isolated conical and razor-backed hills occur, which form a peculiar feature in this district. In all cases they are capped by a quartz reef or lode, whose presence has protected them from denudation. They are very characteristic of this part of Zululand and are shown on (Pl. i., Figs. 1 and 2).

Recent and Pleistocene.

The rocks representing these formations consist of the alluvial detritus, which has been deposited by the rivers, in the more open portions of the valleys and at the points where they debouch on to the littoral; together with the wind blown sands of the littoral.

With reference to river alluvials not much need be said, as they are rarely deposits of any great thickness or extent, owing to the high grade of the rivers and their rapidity of flow during flood-times. It is true, that, in places where alluvial deposits have been derived from the degradation of the older rocks, containing auriferous reefs or lodes, they may contain alluvial gold and therefore be of some importance from a mining point of view. But, on the other hand, it is a curious fact, that on almost all the richest and most extensive gold-fields in South Africa, the alluvial deposits associated therewith have been of a most disappointing and unproductive kind, as regards their gold producing capabilities. Notwithstanding this, the presence of alluvial deposits are always of value to the prospector, because the materials of which they are made up, give a clue to the geological and mineralogical structure of the country within the drainage area of the river, in the basin of which, the alluvial has been deposited.

Whenever alluvial deposits do occur, they are commonly taken advantage of, by the native, for the purposes of cultivation, because the soil which covers them is usually very rich in quality. Over most of the area occupied by the coal-bearing formation, the soils have necessarily a deficiency in lime, because limestone is a rock which is poorly represented among the coal-bearing strata. On the other hand, the soils of the northern portions of the littoral, contain a comparatively large percentage of lime, owing to the fact, that among the Mesozoic beds which underlie the Pleistocene and Recent sands, the majority are calcareous.

There is an extensive development of Pleistocene and Recent deposits over the littoral portion of Zululand. These consist chiefly, of wind-blown sands, which occur abundantly in the neighbourhood of the coast line, in the form of ridges and hills, with occasionally extensive open wastes of sand. As there is no doubt, that the littoral has been at no distant time a portion of the sea-floor recently elevated into dry land, the major portion of the sand has originated as sea-worn sand. On the

littoral, inland of the sand dunes of the coast line, Pleistocene deposits, consisting of sands, clays, friable limestones, &c., occur. These, however, have been deposited either in the neighbourhood of the river channels, or in the waters of lakes and lagoons. In all cases, they show a certain amount of stratification, and in some localities they are decidedly fossiliferous. Such a locality occurs in the neighbourhood of Lake Sibayi, from which I received some specimens, sent me by Mr. Crossly of Makowe. These were chiefly calcareous earthy deposits, and slightly impure whitish limestones. An examination of these was kindly made for micro-organisms by Mr. G. J. Hinde, of the South Kensington Museum, London. Speaking of the limestone, Mr. Hinde says: "The thin section showed that the rock consisted mainly of finely" "granulated carbonate of lime, in which some quartz-sand grains were" "dispersed. Sections of small organisms, probably Ostracoda, with" "thin shells, are present, but no traces of spicules nor of diatoms" (Mr. Etheridge, of the Sydney Museum, mentions the occurrence in a specimen that he examined of "intensely small frustules of Diatomaceæ" "and sponge spicules of a very simple character. The latter are very" "similar to spicules found in the Diatomaceous earths of New South" "Wales.") Mr. Hinde further states: "The only residue after treat-" "ment with acid consisted of rounded and sub-angular grains of quartz" "and some other minerals, also one or two minute sponge spicules." "The spicules are simple acerate forms, with small surface prickles;" "they are about 0.19 mm. in length, by 0.01 mm. in thickness." "Spicules of this form and size are of common occurrence in fresh" "water siliceous sponges, but they are not characteristic of any par-" "ticular genus or species. Mr. Etheridge mentions the occurrence of" "some indistinctly preserved diatom frustules, in the rock, but I failed" "to find any traces of these organisms in the residues after acid." "Besides probable Ostracoda there are numerous hollow casts of a" "small Gasteropod shell shown on the surface of the specimen The" "casts are not more than 2.5—5 mm. diameter. there are from 4—5" "whorls. Wax squeezes of the casts show the form of the shell fairly" "well. It bears a very close resemblance, save in size, to *Planorbis*" "*pfeifferi*, F. Krauss, and it may possibly be a small variety of this" "species. Krauss' type-form came from Post-pliocene deposits in the" "Umgeni Valley, Natal. The species has lately been described and" "figured by Mr. R. B. Newton, F.G.S., from the Nile Valley*" "Through the kindness of Mr. Newton I have seen some of the" "examples from Egypt, but I have not seen any of those from Umgeni," "Natal."

Mr. H. C. Burnup of this city, who has made a special study of the Recent Conchology of this part of South Africa, and possesses one of the best collections of Recent shells in the country, informs me that the species *Planorbis pfeifferi,* F. Frauss, is a fairly common shell, both in Natal and Zululand at the present day.

In the Post-tertiary alluvials of our river valleys, which are certainly scanty, and among the other deposits of a similar age, the raised beaches

*Geol. Mag., Ser. 4, Vol. VI., 1899, p. 403, Pl. XIX., fig. 6—8.

and wind-blown sands of our coasts and the alluvial deposits of the littoral of Zululand, a fertile field for scientific investigation presents itself. Here we have the deposits, intervening between the present day and Tertiary times, among which we may expect to find, the forms, which would show the development of our Recent Conchology from that of the Tertiary rocks which occur so plentifully, and are so fossiliferous, along the littoral of Northern Zululand, Amatongaland, Portuguese Territory, Sofala, and the west coast of Madagascar.

Cretaceous Rocks.

I have been able to visit three localities in Zululand where outcrops of these rocks occur. They are usually situated at points where the littoral joins the foot-hills of the Uplands. One of these is on the south bank of the Umfolosi river, close to Lake Isitesa, and about 20 miles above its mouth. Another is on the Umsinene river, some miles to the west of the north end of False Bay, a portion of St. Lucia Lake. The third is in the bed of the creek, about a couple of miles to the east of Crossly's Store, Bombeni, near the southern end of the Lebombo Range. Other outcrops are reported to occur further to the north, at Amavene Hill, on the Pongola river, on the eastern flank of the Lebombo Range; and also at a point some miles to the north of the junction of the Ingwavuma with the Pongola river. I have also reason to believe, that they crop out on the edges of the waterway which connects Lake St. Lucia with False Bay. There is no doubt in my mind, that this formation is largely developed over the northern portion of the littoral of Zululand, but is hidden, in the majority of cases, by the overlying Pleistocene and Recent sands. When boring for coal near the mouth of the Umhlatuzi river, it was proved by two bores, put down under the supervision of Mr. A. Cowley, superintendent of diamond drills for Zululand, to exist in the form of fossiliferous limestone at a depth of 70 and 90 ft. respectively. This fossiliferous limestone is identical with the Cretaceous limestone mentioned above, as occurring at Umkwelane Hill on the Umfolosi river. The overlying deposits were Pleistocene sands. The bores were put down to ascertain whether the coal measures of the Umlalaas coal-field existed near the coast, at the mouth of the Umhlatuzi river, but no results were obtained, as the bore was stopped in the Cretaceous limestone, the formation overlying the coal-measures, instead of being carried through it. There is every likelihood that the coal-measures do exist here underneath the Cretaceous Formation, which is probably of no great thickness in this neighbourhood. It would be impossible to say, with our present knowledge, as to the depth at which they occur, or as to the presence of productive coal-seams among them. This limestone crops out in the cliffs, higher up the coast, to the south of the Umfolosi river. It is probable that the thick beds of lignite and marls reported from this part of the coast, will be found to be associated with these Cretaceous rocks, although it is not impossible that Tertiary strata may occur, in places, overlying the Cretaceous beds along this coast, as it does further to the north. Between the eastern side of the

Lebombo Range and the coast, similar fossiliferous beds occur in Amatongaland, immediately to the north of Zululand. They again occur still further to the north, in the district of Sofala, beyond Delagoa Bay; while in the western portion of the island of Madagascar they attain a great development, and are there, overlaid by a series of rocks of Tertiary age. The only part of the west coast of Africa, south of the equator, from which outcrops of Cretaceous rocks have been recorded, is on the north shore of the mouth of the Congo river. Here they are associated with Tertiary rocks, but so far they have not been worked up, to any extent, and no definite knowledge exists as to what portions of the Cretaceous formation they represent, or the Palaeontology of the series.

To the south, along the eastern coast of Natal, these rocks are not known to occur from near the mouth of the Umhlatuzi river in Zululand to a considerable distance south of Port Shepstone, on the south-east coast of the Colony. They outcrop at intervals, as far south along the coast as the mouth of the Umtata river in Kaffraria, and on no other part of the coast of Cape Colony are they known to exist. The Calcareous sandstones, which rest uncomformably on the Ecca Series and form the Bluff at Durban, may belong to this series, but as they have so far proved to be unfossiliferous, and as they show no stratigraphical relations to any rocks newer than the Ecca Series, their age must remain unknown, at least, for the present.

As has been previously stated, fossiliferous Cretaceous rocks have been known to occur on the south-east coast of Natal. They have been described by Captain Garden, Mr. W. H. Baily, and Mr. C. L. Griesbach, who mentions the occurrence of similar beds in a stream running into St. Lucia Lake, in Zululand. This is probably the same locality I refer to above as the Umsinene river. A few years ago, in 1896, Mr. R. Bullen-Newton gave a *resumé* of previous researches on the Cretaceous Conchology of Southern Africa, together with a list of all the fossil forms which have been obtained from South African localities, including Madagascar. In these papers, only casual mention is made of the fact, that fossiliferous Cretaceous rocks are reported to occur near St. Lucia Lake, Zululand; so that the present collection which I obtained last year, is the first that has been brought together. I have forwarded the bulk of the collection to Mr. R. Etheridge, Junr., Curator of the Australian Museum, Sydney, who has kindly undertaken to examine and identify the specimens.

The fossiliferous beds exposed in the various localities are all of marine origin, and consist of conglomerates, calcareous sandstones, limestones, chalk and chalk marls. Near Crossly's Store, the rock is a coarse calcareous conglomerate, evidently a beach deposit. It is exposed in a shallow creek bed and is very fossiliferous. As might be expected, the fossil shells are, as a rule, very imperfect, being much broken and worn by attrition. They consist chiefly of large Gastropoda, with a much less percentage of Lamellibranchiata, while Cephalopoda are rare. This rock has a light yellow calcareous matrix, while the pebbles usually consist of quartzites and other altered sedimentary rocks,

with well rounded fragments of amygdaloidal basalts and other volcanic rocks. The outcrop occurs, at the foot of the eastern slope of the Lebombo Range, which is composed of a light coloured Rhyolitic rock, but so far as I have seen, no undoubted pebbles of Rhyolite could be identified in the fossiliferous conglomerate, although the peculiar yellow colour of the calcareous matrix may have been due to the presence of the fine clay, which results from the disintegration of this rock. Fossil wood occasionally occurs, showing the borings of a Toredo. The outcrop of the conglomerate is of limited extent, as it only occurs for a short distance in the bed of the creek, and then disappears under the Pleistocene and Recent sands of the littoral.

At the Umsinene river, the rock is a fine grained calcareous sandstone of a greenish yellow colour. Its chief characteristic is the large quantity of Toredo bored fossil wood which it contains. Ammonites and Lamellibranchiata are plentiful, while Gastropoda are not common. A large form of Ammonite occurs here, over a foot in diameter. The exposures of these beds are only locally fossiliferous, and, even in such positions, the individual fossils are not very abundant. Between the Lower Umfolosi river and the Isitesa Lake, there is an outcrop of Cretaceous rocks, which form the Umkwelane hill The fossiliferous bed is an impure limestone of a bluish grey colour, which outcrops near the bottom of the eastern slope of the hill. It is overlaid by an earthy-coloured calcareous sandstone, which forms the summit of the hill, and bears a close resemblance to the rock at the Umsinene river, except, that, in the Umkwelane rock I saw no traces of fossils. The limestone is uniformly fossiliferous, and, usually, the fossils predominate over the matrix. The most common forms are the Lamellibranchiata and Gastropoda, while the Cephalopoda are rather rare. Polyzoa are very rare, and only occasional fish teeth are to be found.

The outcrops of these Cretaceous rocks, which I have had an opportunity of visiting, in every case, are most limited in extent. With the exception of the Umkwelane hill, on the Lower Umfolosi, where the greenish-yellow sandstone overlies the fossiliferous limestone, there are no sections showing the continuity or superposition of the beds forming the Cretaceous series, and the various outcrops are so isolated and far apart, that it is, as yet, impossible even to draft a scheme of the succession. But, in reference to this point, I may mention that some miles up the coast, to the north of the mouth of the Ecwebeni lagoon, into which the Umhlatuzi river flows, the cliff sections exposed consist frequently of the fossiliferous Cretaceous limestone, described above, while in places they are formed of clays, sands, and lignites. I have not yet had an opportunity of seeing a section which would show the relation of these clays, sands, and lignites to the underlying Cretaceous limestones, so that, at present, I am unable to say whether the lignite-bearing series forms part of the Cretaceous, or represents the Tertiary Formation, which is present higher up the east coast, and on the west coast of Madagascar, overlying the Cretaceous Formation,

In the south, at the mouth of the Umhlatuzi river, the Cretaceous rocks, in all probability, rest unconformably on the coal-measures of the

Umlalaas coal-field. Further to the north, on the littoral, they probably rest on the thick series of basaltic rocks which overlie the coal-measures of the St. Lucia coal-field, as far north as the Umsinene river; while still further to the north, in the region of the lower end of the Lebombo Range, they probably rest, at least, in the neighbourhood of the range, on the Rhyolitic lava, of which it is formed.

Outcrops of rocks, of many descriptions, are reported from the immediate coast-line of the more northern part of the Province; but, as a rule, their descriptions are not sufficient for their identification, and, until an opportunity occurs for their examination, they will probably remain unknown. As will be mentioned later on in this report, there is the likelihood of rocks of economic value occurring among these Cretaceous strata, including lime, pottery clays, marls, &c., &c.; and, therefore, the investigation of the occurrence and extension of these deposits is of considerable importance.

In all cases the Cretaceous rocks rest unconformably on the formations underneath. From their occurrence and disposition along the littoral it is evident that, after the main elevation of the southern part of the continent, they were deposited as a fringe, around the eastern and south-eastern coasts, and their outcrops are now exposed on the land, through the slow continuation of the elevating forces, which are still imperceptibly raising the coast-line of Zululand and Natal.

It will not be out of place here to give a list of the Cretaceous fossils, that are at present known, from the Upper Cretaceous rocks of Natal, as given by Mr. R. Bullen Newton.*

Upper Cretaceous Mollusca from South Africa, with their Geological Ranges According to Indian Nomenclature.

Abbreviations—A.=Ariyalur group=Senonien (Upper Chalk).
T.=Trichinopoly group=Turonien (Lower Chalk).
U.=Utatur group=Cenomanien (Chalk Marl, Chloritic Marl, Upper Greensand, and Gault).

Cephalopoda.

Anisoceras rugatum, Forbes	...	...	...	U
Baculites sulcatus, Baily	...	...	...	U ?
Lytoceras Kayei, Forbes, sp.	...	...	...	U
Puzosia Gardeni, Baily, sp.	...	...	...	A
Puzosia rembda, Forbes, sp.	...	...	...	U
Schloenbachia Soutani, Baily, sp.	...	...	...	U
Schloenbachia Stangeri, Baily, sp.	...	...	...	U
Schloenbachia Umbolazi, Baily, sp.	...	...	...	U

*The Journal of Conchology, Jan., 1896, vol. viii., No. 5, pp. 148—149.

GASTROPODA.

Avellana ampla, Stoliczka	T
Cerithium (Fibula?) detectum, Stoliczka	A
Cerithium kaffrarium, Griesbach	T
Euchrysalis gigantea, Stoliczka	TA
Fasciolaria assimilis, Stoliczka	A
Fasciolaria rigida, Baily. sp.	T
Lagena nodulosa, Stoliczka	TA
Natica multistriata, Baily	T
Pollia pondicherriensis, Forbes, sp.	T
Pugnellus uncatus, Forbes, sp.	TA
Scala turbinata, Forbes, sp.	A
Solarium pulchellum, Baily	T
Solarium Wiebeli, Griesbach	T
Tritonidea trichinopolitensis, Forbes, sp.	T
Turbonilla undosa, Forbes, sp.	T
Turritella multistriata, Reuss	TA

SCAPHOPODA.

Dentalium, sp.	T

LAMELLIBRANCHIATA.

Alectryonia ungulata, Schlotheim, sp.	A
Arca capensis, Griesbach	T
Arca umzambaniensis, Baily	T
Astarte, sp.	T
Axinæa africana, Griesbach, sp.	T
Cardium denticulatum, Baily	T
Corbula, like C. carinata, d'Orbigny	T
Cucullæa natalensis, Baily, sp.	T
Inoceramus expansus, Baily	A?
Meretrix arcotensis, Forbes, sp.	T
Neithea quinquecostata, J. Sowerby, sp.	UTA
Nucula, sp.	T
Ostrea, sp.	T
Pecten amapondensis, Griesbach	T
Poromya ?	T
Protocardium Hillanum, J. Sowerby, sp.	T
Teredo, sp, ...	U
Trigonia elegans, Baily	T
Trigonia Shepstonei, Griesbach	U

Below I give a list, by the same author, of the fossils which have been obtained from the Cretaceous rocks of Madagascar.*

Nautilus Fittoni, Sharpe.	Upper Cretaceous.
Belemnites conicus, Blainville.	Neocomian.
Belemnites polygonales, Blainville.	
Belemnites pistilliformis, Blainville.	
Belemnites binervius, Raspail.	

* Quart. Journ. Geol. Soc., London, Vol. LI., p. 89. 1895.

LAMELLIBRANCIATA.

Alectryonia ungulata, Schlotheim.	Upper Cretaceous.
Alectryonia pectinata, Lamark.	Upper Cretaceous.
Alectryonia Deshayesi (?), Fischer de Waldheim.	Upper Cretaceous.
Gryphæa vesicularis, Lamarck.	Upper Cretaceous.
Exogyra ratisbonensis, Schlotheim.	Middle Cretaceous.
Lima, sp.	Neocomian.
Pecten, sp.	Neocomian.

ECHINODERMATA.

Lampadaster Grandidieri, G. Cotteau.	Upper Cretaceous.
Guettaria Rocardi, G. Cotteau.	Upper Cretaceous.

FORAMINIFERA.

Globigerina, sp.	Upper Cretaceous.
Frondicularia, sp.	Upper Cretaceous.
Nodosaria, sp.	Upper Cretaceous.
Bulimina, sp.	Upper Cretaceous.

COAL-BEARING FORMATION.

The area in which coal is known to occur in Zululand is of great extent, covering, as it does, the major portion of the Province, and stretching from near the Tugela river, with a few local exceptions, where the metamorphic and other rocks appear at the surface, to the north of Nongoma and into Swaziland. In fact, these older rocks have been, especially in the western part of the Province, exposed by the denudation of the overlying coal-bearing formation. To the north-east of the lower portions of the Umfolosi river, and in the eastern part of the Makowe hills, large developments of basaltic rock occur, overlying, and apparently conformable with, the coal-bearing strata. These have evidently been contemporaneous lava-sheets, are often amygdaloidal, and attain a considerable thickness. In occurrence and character, they bear a striking resemblance to the series of amygdaloidal basaltic rocks which overlie the coal-bearing series of the high veld of the interior. The coal-bearing strata consist of shales, often fossiliferous, sandstones, and coals, calcareous beds being of rare occurrence. They are seamed with dykes and sills of subsequently intruded basaltic rocks. Wherever I have had an opportunity of observing the relations of this series to the Dwyka Conglomerate they appear to be conformable, with the intervention of a set of dark-coloured shales, which so commonly overlie the Dwyka Conglomerates, wherever the latter occur, and which exhibit similar petrological characters to the matrix of that glacially-formed deposit. This can be readily noted in the district to the north of the mouth of the Tugela river, where the sections exposed show the passage from the Dwyka Conglomerate, through the dark-coloured shales into the coal-bearing sandstones and shales of the Umlalaas coal-field. In this district, on the Umlalaas river, the unconformity between the coal-bearing series

and the metamorphic granites, gneisses, and schists of the Engoye Mountains can well be seen, while on the northern side of the range they are faulted against these metamorphic rocks.

Many bores have been put down in the various coal-fields, but, in the majority of cases, where coal was struck, it proved to be of a decidedly anthracitic character, although, in some instances, fairly good bituminous coal has been proved to occur. None of these were put down as government bores, for the purpose of testing the thickness of the coal-measures, the position and presence of coal-seams and the succession of strata forming the coal-measures. They were, in all cases, put down by private syndicates or individuals, with the assistance of government, for the specific purpose of finding coal on the land owned by the syndicate or party. The result of this has been, that in no single instance has the bore done more, than prove to these people, either, that they had a coal-seam on their property, or else a basaltic sill, in which, in the majority of cases, they have stopped boring, having made no attempt to test the beds lying below such a volcanic rock. Consequently, we are in the position of knowing nothing of the deeper beds of the coal-bearing series, because all the bores have been of a more or less superficial character. We possess a general knowledge of the series of beds between the coal-bearing portion of the Eccas and the Dwyka Conglomerate, which limits in depth the occurrence of coal. Undoubtedly, at Vereeniging, in the Transvaal, coal-seams are associated with the Dwyka Conglomerate, which, there, as in Natal, rests unconformably on the underlying formation. So far as our knowledge goes, there is no instance of coal occurring, either in Natal or Zululand, so low down in the series as at Vereeniging. In fact, the usual succession is as follows:—Dwyka Conglomerate; black carbonaceous shales with light-coloured sandy shales (the Ecca Shales); sandstones, shales, and coals, (the Ecca coal-bearing series). In the St. Lucia coal-field, in the Umlalaas coal-field, at Nongoma, and at Umhlali, in Natal, the coals outcrop among the last-named series, and most of the bores have been put down in this series, but have not gone lower. Taking into consideration the want of uniformity of deposition which has existed among the Ecca beds, and the irregularity, as compared with the Ecca Series in the Transvaal and the northern Cape Colony, I think it would be, at least in some cases, an absolute necessity, in boring to prove the presence of coal, to go as deep as the Dwyka Conglomerate. In any case, it is simply absurd to stop boring because a volcanic sill is met with, as these sills do not represent any particular horizon, but occur in a most erratic manner at all levels throughout the whole series.

Some miles south of Nongoma a coal-seam crops out close to the road, and could easily be worked by adit. The chief amount of prospecting and boring has naturally been done on the Umlalaas coal-field, the nearest to the Natal railway. In a year or two the Natal-Zululand railway will be completed as far north as the St. Lucia coal-field, so that, as this railway passes through the Umlalaas and St. Lucia coal-fields, and is within a short distance of the others, an impetus should thereby be given to the development of the Zululand coal-fields.

Little or no information is to hand with reference to the coal-producing capabilities of the Ecca Series in the interior, as almost all the prospecting has, previously, been confined to the outcrops of the coal-bearing rocks, in localities near the coast. As shown by the outcropping of the Dwyka Conglomerates in the west, on the Transvaal border, north of Entonganeni and Ulundi Plains, the coal-bearing series thins out in that direction, but, between the coastal outcrops and the outcrop of the Dwykas in the west there is a very considerable area of country in which the coal-bearing rocks occur, among which coal-seams may be expected to be present.

Although, in the majority of cases where the coal, in Zululand, has been sunk upon, it has been found to be, of an anthracitic kind, it does not necessarily follow that all the coal-seams which exist yet undiscovered in the coal-bearing strata of the Province, are also anthracites. It is to be remembered, that only in a very few localities have the coal-bearing rocks been prospected for the presence of coal, and that only by shallow bores, and shafts, and on the decomposed outcrops of the coal-seams. The localities in Zululand, where the actual presence of coal-seams are known, are remarkably few and far between, when one takes into account the large area of the Province, over which the coal-bearing strata outcrop. This is doubtless due to the fact, that prospecting has only been carried on in such localities, where there would, in the near future, be a chance of having cheap carriage, either by prospective railway line, or water carriage from the mouths of some of the larger rivers. It is needless to say, that little or nothing is, as yet known, either as regards the actual thickness of the coal-bearing series, or the number and position of the coal-seams which occur therein. This can only be remedied by a systematic geological survey.

In almost every known coal-field, anthracitic coals occur, and in fact almost all bituminous coal-seams are locally anthracitic. These two varieties of coal often pass, by insensible gradations, from one to the other in the same seam. Indeed, in our own coal measures in the northern parts of Natal, we have examples of this, portions of bituminous coal-seams possessing an anthracitic character. This is particularly common in the neighbourhood of intrusive rocks. In some localities, however, as in the County of Kilkenny, in Ireland, no bituminous coals exist, all the seams being entirely of an anthracitic character, The chief coals worked in Pennsylvania, America, are anthracites, the export of which has gradually assumed very large proportions, particularly during the last year, when a new export trade was opened up with Europe, to which large quantities were exported. Prices for this class of coal have been very high, especially for the better qualities, used for malting, &c. It is largely used for metallurgical purposes, particularly in iron and blast furnaces, although it is unsuitable for reverbatory furnaces. Traces of the fossil plants of which anthracite is composed, are never met with, and the ultimate result of the metamorphism of such a plant deposit, is graphite or plumbago, which frequently occurs in this country, as the result of the alteration of very carbonaceous shale or coal, by the near presence of an intrusive mass of volcanic rock.

In America, this form of coal is generally used for household and general purposes. In fact, in the larger cities its use is enforced, because it burns with a smokeless flame, and therefore the smoke nuisance of cities is, to a large extent, mitigated. Although they yield a non-coherent coke, still, because of the intense heat which they give out, they are most valuable as a metallurgical fuel.

The coal-bearing area has already been divided up into separate coal-fields, which are usually defined by some geographical boundary, which in some cases, is also a geological one. Thus the Umlalaas Coal-field, the furthest south, some twenty miles north of the Tugela river mouth, is separated from the Ntambanana Coal-field, on the north-west, by the presence of the Engoye Mountains, which consist of metamorphic granites, gneisses, and schists, while it is restricted on the east by the sea. Intervening between it and the St. Lucia Bay coal-field, are a series of basaltic lavas, of considerable thickness, which seem to overlie conformably the coal-measures of the latter coal-field.

The following is a list of the Zululand coal-fields:—

St. Lucia Bay Coal-field (West of St. Lucia Bay).
Umlalaas Coal-field (East of Eshowe).
Ntambanana Coal-field (Lower Umfolosi).
Umhlatuzi Valley Coal-field (North of Eshowe).
Hlopekulu Coal-field (Entonjaneni).
Qudeni and Madhlozi Coal-field (Nkandhla District).
Langagazi Coal-field (Nqutu District).
Nongoma Coal-field (Nongoma).

The Umlalaas coal-field is situated to the east of Eshowe, and is bounded on the south-east by the sea, and on the north and west by the metamorphic rocks of the Engoye Mountains; while to the south-west, it merges gradually into the series of shales, overlying the Dwyka conglomerate, which form the undulating country toward the Lower Tugela. To all appearance, the Umlalaas coal-bearing strata form a conformable series, with the thick set of black shales above mentioned, which occur around Bond's Drift. These shales are characterised, by the total absence of sandstone beds among them. They are usually carbonaceous, but in no instance have I met with any traces of fossils, either plants or animals, among them. As a rule, they dip at a low angle towards the coast. A good section of them can be seen in the Matikulu river, at Fort Crealoch, where they dip about 15° to the east. Unlike the St. Lucia coal-field, the coal-bearing series of the Umlalaas district are not overlaid by basaltic rocks, except where the latter form the ordinary intrusive sills, which have been exposed by denudation. This coal-field, as being the nearest to the market, by the north-coast Natal railway, has naturally had more attention paid to it, in the way of preliminary prospecting, than any of the other fields. Within the last few months, attention has again been directed to it, and, I believe, that at least one syndicate has started to prospect their ground thoroughly.

A considerable number of borings have been made, particularly in the neighbourhood of the lower part of the Umlalaas river. Those sunk

near the mouth of the river passed through the usual series of shales and sandstones. and, occasionally, igneous rocks. In most of them, seams of coal were passed through, which varied in thickness from a few inches, up to solid seams of 1ft. 8in., while in one bore (No. 22), nine feet of alternating shales and coals occurred, the aggregate thickness of the coal approximating to between four and five feet. Most of these coals are of an anthracitic character, although, in one case, at least, a bituminous seam of 1ft. 5in. occurs, which, however, by analysis gave over 24 per cent. of ash. Borings have also been put down near the main northern coast road, in the neighbourhood of One Tree hill; but, in this locality, the coal-seams occurred less frequently in the bores, which were, however, of very shallow depths. The majority of the bores put down on this coal-field were within a mile or two of its northern boundary, where the coal-bearing series rests unconformably on the gneisses and schists of the Engoye Mountains, and gradually thin out against these metamorphic rocks. The probability is, although no bore has yet proved the point, that in close relation to this boundary of the coal-field the thickness of the whole series will not be great, and, certainly, much less than it will be some distance to the south. We do not get, abutting against the metamorphic rocks of the Engoye Mountains, either the Dwyka Conglomerate or the lowest shale beds of the series, showing that along this boundary of the coal-field, during the deposition of the coal-bearing strata, this area of metamorphic rocks, which now forms the Engoye Mountains, must have stood out, surrounded by a precipitous insular coast-line. On its northern side, we get, near Eshowe, the Dwyka Conglomerate at the surface, while down towards the Tugela river we gradually pass off the coal-bearing series, on to the dark shales, which intervene between them and the Dwyka Conglomerate, which is exposed over a wide area, along the valley of the river. The thickest part of the coal-bearing series will, therefore, probably be immediately to the south of the road, between the Umlalaas Magistracy and the store, at the Inhlababa range. There is no doubt, I think, that these coal-bearing beds exist to the north-eastward of the Umlalaas river mouth, on the flat littoral, past Fort Durnford, and the lagoon into which the Umhlatuzi river flows. Here they are covered, not only by the Pleistocene and Recent sands, but also, as proved by the bores put down to the north of the lagoon, by fossiliferous limestones, similar to those of the Umkwelane hill, on the Lower Umfolosi river, which are probably of Cretaceous age.

The St. Lucia coal-field is situated in the Hlabisa District, in the basin of the Enseleni river, which flows into the southern end of False Bay, the western portion of Lake St. Lucia. To the south-west it is continuous across the junction of the White and Black Umfolosi rivers, with the Ntambanana coalfield. The area of the Ecca coal-bearing rocks of this coal-field is limited on the south and north by the presence of a considerable thickness of basaltic rocks, which seem to overlie the coal-measures conformably, and, to the north, form a large portion of the eastern half of the Makowe hills. Towards the Hlabisa Magistracy it is curtailed by the presence, at the surface, of the Dwyka Conglomerate

resting upon the fundamental granite, and also by the thick series of sandstones which form the western half of the Makowe hills, and are probably of Palaeozoic age.

On the western side of the northern-coast road, at St. Lucia coal-field, outcrops of coal occur in the nearest creek-bed. Like all our coals, it varies considerably, and, within a thickness of some 50 feet, various solid coal-seams occur, ranging from 6 feet to 15 feet, with intercalated shales. Little or no development has taken place here, but, with the advent of the railway within a short time, there should be a considerable impetus given to the exploitation of this coal-field.

Some miles to the south of the Nongoma Magistracy, a coal-seam outcrops close to the west of the main road. This coal has been for some time excavated, in a rude way, for use by the residents around the magistracy. It is an anthracitic coal, and at the point where it has been opened, is of considerable thickness. It occurs among a set of black carbonaceous shales, which are approximately horizontal, so that the exploitation of this coal would be easily done, by adit, as the country in the neighbourhood is of a more than hilly character. Near the magistracy itself, black shales occur, which are abundantly fossiliferous, containing chiefly the remains of plants, of which the most common is *Glossopteris Browniana* Brong., either the variety *indica*, or the variety *angustifolia* Brong. These coal-measures are a continuation of the Ntambanana and St. Lucia coal-field across the valleys of the White and Black Umfolosi rivers, and some miles past Nongoma they cross the border into the Transvaal, and continue northwards, for some distance, where they ultimately thin out against the granites, gneisses, and schists of Swaziland.

Southward from Nongoma, the coal-measures gradually thin out, until some miles north of Mahlabatini Magistracy, we come upon those slate-like beds, with nodules of pyrites, which are associated with the Dwyka Conglomerate, and ultimately on Ulundi Plains the Dwyka Conglomerate itself is exposed.

Of the other coal-fields little is known, except perhaps the actual presence of a coal-seam.

The known palæontology of the coal-bearing rocks of Zululand, is of the most meagre description. The small collection of fossil plants, which I made at St. Lucia Bay Coal-field and Nongoma, together with a number of specimens which were kindly lent me by Mr. D. Brown, of Darnall, Victoria County, have been examined by Mr. Robert Etheridge, Junr., of Sydney Museum. From his examination of these fossils, which were of a very imperfect character, Mr. Etheridge correlated the coal-bearing beds of the St. Lucia and Nongoma coal-fields with the Upper Coal-Measures of New South Wales, Australia, which are recognised to be of Permo-Carboniferous Age. There is no doubt in my mind, from the stratigraphical evidence in the field, that the series of beds containing the coal-seams, both at St. Lucia and Nongoma, rest conformably, upon the series of carbonaceous shales overlying the Dwyka Conglomerate, which can be seen outcropping in the neighbourhood of the Hlabisa Magistracy. This

is identically the same succession, which occurs, on the north coast of Natal, at Umhlali, between the glacial Dwyka Conglomerate and the Ecca coal-bearing series, and in the latter case the same fossil plants occur, chiefly *Glossopteris* and *Phyllotheca*. This, I think, leaves little doubt that the coal-bearing series of Zululand belongs to the Ecca Series of the Lower Karoo Formation. For the sake of comparison, I give below a list of the fossil species, from the Ecca beds of the Transvaal, and from St Lucia Coal-field, Zululand.

PLANTES.	Vereeniging.	Casey's Township (Francis).	Boschmansfontein & Maggie's Mine.	St. Lucia Coalfield.
Glossopteris Browniana, Brong.	*X	*X	*...	...
Glossopteris Browniana var. *Indica* Bunbury ...	X	X	X	X
Glossopteris Browniana var. *angustifolia* Brong.	X	X	...	X
(Vertebraria) Indica, Royle	X	X	X	...
Noeggerathiopsis Hislopi, Bunbury ...	X	X	X?	...
Gangamopteris cyclopteroides Feist. ...	X	X	...	...
Phyllotheca	...	X	X	X
? Equisitaceous stem of. *Calamites* ...	X	...	...	...
? *Sigillaria* sp.	X	...	...	...
Sigillaria Brardi, Brong.	X	...	...	...
Conites sp.	X	...	...	...
Cardiocarpus sp.	...	X	...	...
Sphenopteris sp.	...	X	...	...
Glossopteris damudica var. *stenoneura* Feist. ...	...	...	...	X
Glossopteris retifera Feist.	...	...	...	X
Glossopteris acuta Dun.	...	...	...	X
Glossopteris spatulo-cordata Feist. ...	...	...	...	X
Angiopteridium spathulatum McClelland ...	...	...	...	X
Myiston cyclopteroides	X	...	...	...
ENTOMOSTRACA.				
Estheria Greyii Jones	...	...	...	X
PISCES.				
Ganoid scales	...	...	...	X

DWYKA CONGLOMERATE.

Outcrops of the Dwyka Conglomerate, occur in various districts of Zululand. It usually occupies the lower portions of the valleys, being overlaid by the Ecca coal-bearing series, which generally form the hills

* Seward, A. C., "On the Association of Sigillaria and Glossopteris in South Africa." Quart. Jour. Geol. Soc. London, Vol. liii., p. 315.

of the upper portion of the country. Around Bond's Drift on the Tugela River, the rock is of a most typical character. A few miles northward into Zululand, it is overlaid by the usual series of carbonaceous shales, and by the coal-bearing series of the Umlalaas coal-field. It does not occur on any part of the coast, nor for a long distance inland. In the neighbourhood of Hlabisa magistracy, there are a number of isolated outcrops. On Ungangatu Hill, some miles to the north it is present, overlying a thin bed of conglomerate, composed of well rounded water worn pebbles, which rests unconformably on the granite underneath. In the valley of the Umona River, about three miles west from Ungangatu hill, outcrops of Dwyka Conglomerate occur at a much lower level. Here, it is accompanied by a series of very fine grained blue rocks, which are of a somewhat fissile character, and split in uneven slabs, usually about an inch in thickness. Some miles to the north of Mahlabatini magistracy, an outcrop of these fine grained, somewhat fissile rocks occur, close to the main road, associated with the Dwyka Conglomerate. A feature of them, here, is the presence of isolated segregation nodules of copper pyrites, often as large as one's fist. On the plains of Ulundi, the Dwyka Conglomerate forms the surface rock.

The presence, at the surface, of the Dwyka Conglomerate, in any district is of importance, from the fact, that in most parts of South Africa, the ores of metals of economic value occur chiefly in rocks which are older than this formation, and therefore have to be looked for below it. On the other hand all our coal-bearing rocks are younger than the Dwyka, and therefore will occur overlying the glacial conglomerate. Its presence always limits the area of the coal-bearing rocks.

Palæozoic Sandstones.

Representatives of this formation do not occur in the coastal area. In the western portions of the Province, however, they are locally, largely developed. Some miles above Bond's Drift, on the Tugela River, they outcrop over a considerable area, while to the north and north-west, they are occasionally exposed, forming the typical flat-topped hills that are so characteristic of their denudation. This formation also occurs in the neighbourhood of the Ulundi Plains, where it is associated with auriferous conglomerates, which are probably the basement beds of the sandstone series.

The large area of thick-bedded sandstones lying to the north-west of the St. Lucia Coal-field, and around Hlabisa, forming the western half of the Makowe hills, and associated in the neighbourhood of Hlabisa with granites, and the Dwyka Conglomerate, may probably belong to this formation.

Granites, Gneisses, and Schists.

These rocks occupy an area of over 300 square miles to the east of Eshowe, and outcrop from a few miles south-west of the Bond's Drift and Eshowe Road, in a north-easterly direction, past the lower Umfolosi magistracy as far as the Imbabe river, where they disappear under the

superficial Pleisocene deposits of sand, which cover the littoral. Around Melmoth, and in the western part of the Province, they are of common occurrence, particularly in the deeper valleys, where they are exposed by denudation, from under the outcrops of the newer formations, which usually cap the ridges and hills. To the east of Eshowe, they form the rugged range of mountains, known as the Engoye Mountains, which attain a height of over a thousand feet, and are locally covered with dense forest. In the higher portion of the range, denudation has exposed these rocks in a profuse manner. The hill faces, looking towards the sea, are usually precipitous, and often show nearly perpendicular cliffs of considerable height. On the top of the range the exposures are more of the character generally exhibited by granitic rocks, forming great isolated blocks, which have been weathered out of the rock-mass, and stand very often on extensive hog-backed weathered surfaces, which are destitute of all vegetation or soil. They consist chiefly of micaceous and hornblendic gneisses, schists, and granite. Often they are purely hornblendic rocks, owing to the small percentage of quartz or felspar that is present. Such rocks may, however, possibly be intrusive, and form dykes of a dioritic character. As a rule, they are seamed with quartz veins of all sizes. The laminations of the gneisses and schists are usually inclined at a high angle, in a direction away from the Engoye Mountains, which form the axis of this metamorphic belt. The gneisses and schists occur on both sides of this central granite core, towards the edges of the metamorphic area. Passing from the central granite axis, to the junction of the metamorphic rocks, with the coal-bearing strata, the gradation from the granite, through the gneisses, to the schists can be well seen, as the various minerals gradually assume a more linear disposition, from the granite of the axis to the edges of the area. The granite of the upper part of the ranges exhibits a considerable amount of shearing. Close to Eshowe, in the neighbourhood of Signal Hill, gold has been found in small quantities associated with these rocks. Its form is peculiar, as it occurs as very fine gold wire. This occurrence of an auriferous lode is associated with the fracture which exists on the northern side of the Engoye Mountains, and is present, past the middle drift of the Umhlatuzi to the Imbabe river.

Basaltic Rocks.

These rocks are usually associated with the sedimentary coal-bearing rocks, in the form of intrusive dykes and sills, which have forced their way between the beds, and rarely as contemporaneous lava-sheets, which have been erupted during the deposition of the beds. They attain their greatest development immediately to the south and east of the St. Lucia coal-field, and north of the Enseleni river, forming the Entondweni mountains and the eastern half of the Makowe hills, passing northward in a broad belt into the South African Republic, to the west of the Lebombo Magistracy. In one case, on the Umsunduzi river, a basaltic dyke occurs, cutting the Rhyolite of the Lebombo range. They are mostly typical dolerites, never attaining great coarseness, although some-

times the felspars are porphyritic, and often they are fine-grained anamesites. In no exposure of Cretaceous rocks have I seen any evidences of intrusive rocks. A few miles below the upper drift of the Umfolosi river a good section of basaltic rocks is to be seen in the Patarre precipice, some hundreds of feet in height. Here there is more than one bed of basalt, but there are no intervening sedimentary beds. This basaltic series overlies the St. Lucia coal-bearing rocks, and, like them, dips at a low angle towards the coast. To the north of the Lower Umfolosi magistracy, the basalts are amygdaloidal in character, the amygdules being commonly some form of silica, such as agate or pebble. These amygdaloidal basalts are, probably, contemporaneous lava-sheets, the amygdules occupying the steam and gas holes which occurred in the viscid lava. In many cases they have a lengthened pipe-like form, owing to the drawing out and lengthening of the gas holes by the flow of the very viscid lava. Such pipe-like amygdaloidal basalts are said to occur overlying the coal-bearing strata of the Upper Karoo, on the plateaux of the Transvaal and the Orange Free State, and are a well-established and easily-determined horizon. Where the main road crosses the Matikula river, basalts intrude carbonaceous shales, and, where the intrusion is thin, it assumes the form of "white trap." In the eastern half of the Makowe hills, a gradual decrease in the individual basalt members, and an increase in the sedimentary rocks, occurs, till after passing Inhlati Mountain the rocks are all sedimentary, with rare intrusions of basalt. Here, and, more particularly, in the Entondweni district, south of the Hluhlue river, it is remarkable to what an extent alteration of the intervening sedimentary beds has taken place, where the thickness of the basalt sills has been very great, in comparison with the thickness of the shales and sandstones between them. These beds altered into a jasperoid flinty rock, and only a few inches in thickness can often be seen in section for long distances between great thicknesses of basaltic rock. To the north of the Lower Umfolosi magistracy, the basalts form the western wall of the lodes which occur along this line of fracture, between them and the gneissic rocks, and it is probable that much of the ferruginous material in the lodes has been derived from those heavy basic basalts. I hope to be able in time to furnish a petrological description of these rocks.

In the northern portion of Zululand the southern extension of the Lebombo range, after passing south of the Umsundusi river, disappears under the Pleistocene sands of the littoral, a short distance south-east of Indulawane Hill, on the Inhlambanyati river. The southern portion of the range, as far as I have traversed it towards the Lebombo magistracy, consists of a rhyolitic rock, approaching in places the character of a quartz-porphyry. It is, undoubtedly, a lava sheet, and it has been noted as forming the Lebombo Range, further to the north, where the latter is the boundary between Swaziland and Amatongaland. Dr. Molengraaff also reports this rock as occurring on the railway line between Delagoa Bay and Koomati-Poort, while it has been traced as far north as the Limpopo river, and there is every likelihood of its being found still further to the north. At those points of the Lebombo Range

at which I saw this rock, there is no evidence as to the source from which it came, but it seems to rest conformably upon the basaltic series which overlie the coal-bearing Ecca Series. Taking into account the large extent of country, to the north, over which it outcrops, and the variety of rock formations with which it is associated, the discovery of the orifice from which the lava flowed, be it fissure or volcano, will prove an interesting one. Near the Lebombo magistracy, where the Umkuzi river cuts through the range, the rhyolite is reported to rest upon gneisses and schists. On its western flank, where the Umsundusi river enters the range, a basaltic dyke occurs, intruding the rhyolite in an east and west direction. It resembles, in petrological characters, the ordinary basalt which occurs so commonly intruding the formations of Natal and Zululand. It is a fine.grained augite-basalt of the common type.

The fossiliferous Cretaceous Conglomerates, which are frequently exposed, flanking the eastern base of the range, contain no recognisable pebbles or fragments of this rock, although the more Recent alluvials consist chiefly of Rhyolitic debris. The denudation of this rock has produced a very rugged range, with deep-cut valleys, stony ridges, and krantzes, while the entire surface of the hills are covered with boulders of all sizes. The resulting soil is of very poor quality, and little or no timber grows on the range, while, except in favoured spots where there are small lakes and springs, the grass is of the most meagre description.

In texture the rock presents many varieties from the original slightly devitrified glass, up to the highly porphyritic Rhyolite. It varies much in colour, but is, as a rule, of a light grey, and passes through all the gradations of ferruginous colourings, to a deep crimson. Locally, chiefly near the bottom of the flow, large patches of the original glassy material still exists. It has, to a slight extent, undergone devitrification, and is of the colour of dark bottle-glass, except where the weathering has picked out the flowage lines, or the perlitic structure, which has given it a streaky, grey appearance (Pl. II., Figs. 1 and 2). In some instances, the glass forms the matrix of a conglomerate which has been produced by the glassy lava, when in a viscid state, before solidification, picking up the pebbles and debris from the surface, over which it flowed. The same also applies to the Rhyolitic agglomerate which occurs so plentifully in the valley of the Manuan Creek, near Crossly's Store. In this case, the glassy matrix has become so devitrified that it presents almost an entirely crystalline base. As a rule, even in the more highly crystalline portions of the rock, there still remains in the base a certain proportion of undevitrified glassy material.

A few analyses of this rock were made for me by Mr. E. Neville, the Government Chemist at the Laboratory, Durban. The specimens were not the best that might have been got for the purpose of analysis, but there were no facilities for obtaining better at the time I visited the Lebombo. As a rule, they were considerably decomposed, but the analyses of two of the freshest specimens, gives the composition of a fairly typical Rhyolite. The other three were, more or less, of the glassy type, with numbers of siliceous pebbles. For the latter reason, the silica percentage is extremely high, in all cases being over 90 per cent.

Supposed Diamondiferous Deposits at Lebombo.

The deposits in the northern part of Zululand, supposed to contain diamonds, because of their fancied resemblance in character and occurrence to the diamond-producing deposits of Kimberley, are situated about two miles to the south-east of Crossly's store, Ebombeni. When in the district, I visited this locality, and examined the deposits in which the diamond prospectors had been working. The reports, as to the actual finding of diamonds here, were of the vaguest description; but, still, a considerable amount of labour had been expended in sinking shafts in various places within the supposed diamondiferous area. This area occurs near the foot of the eastern slope of the Lebombo range, some miles to the north of the Inhlambanyati river, where the range terminates and disappears into the flat sandy littoral. The surface geology of the neighbourhood of the Ebombeni store, and the area in which the shafts have been sunk, is extremely simple in its general features. The range itself consists of a Rhyolitic lava, resting upon the basaltic rocks, which cover such a large stretch of country immediately to the south; while it is flanked to the eastward by a series of fossiliferous Cretaceous conglomerates and sandstones, which, towards the coast, are buried beneath considerable depths of Pleistocene and Recent alluvials and blown sands. The positions of the shafts are well within the area of outcrop of the Rhyolite, and, in some cases, they have been sunk in the surface material formed *in situ* from the decomposition of that rock; while, in others, they have been sunk through the alluvial deposits accumulated in the shallow depressions formed by the periodically-running creeklets which drain this portion of the lower foothills of the range. In the former position the shafts have passed through usually light-coloured, yellow, argillaceous rubble, sometimes ferruginous, and, in the latter, through stratified yellow, white, and mottled clays. In both cases these kaolinised clayey materials are the necessary results of the decomposition of such a felspathic rock as the Rhyolite, whose principal constituent is felspar, which occurs in large quantities as minute microscopic crystals in the base of the rock, and as the chief porphyritic ingredient. The early prospectors thought that these clays presented a resemblance to what is known as the "yellow ground" of the Kimberley mines, and that, because of this fancied resemblance, they would, like the "yellow ground," also contain diamonds. These Lebombo deposits resemble, however, the Kimberley "yellow ground" to this extent only, that they are both of a yellow colour, and are the results of the surface degradation of volcanic rocks. But the character of the original rocks are totally distinct, and their chemical composition, mineral constituents, and mode of occurrence are entirely different; for, it is generally accepted, that the Kimberley rock is of the nature of a volcanic agglomerate filling the old volcanic vent,—while the Lebombo Rhyolite has consolidated as a superficial lava flow. Under these circumstances, it will be seen that the few points of resemblance between the two deposits are so insignificant that, to draw a parallel between the two, and argue the common occurrence of diamonds in them, is, to say

the least of it, very illogical. Erroneous conclusions of this kind are of very common occurrence among prospectors, and are often the source of great loss of time, labour, and money. They are entirely due to the want of a little definite elementary geological knowledge and observation, together with the non-application of ordinary common sense.

In reference to the prospects of obtaining minerals of economic value in that part of Zululand over which I made a hurried journey, it is not too much to say that the production of coal is most likely to be the chief mineral industry. With the exception of coal and gold, which have been prospected for, in a desultory sort of way, no attempt has been made to investigate the occurrence of other commercially valuable minerals. This may have been largely due to the want of a European population, and the absence of an immediate market, together with the heavy expenses of carriage. But, with the throwing open of the country to European occupation in the course of a few years, and the extension of the Natal railway system into Zululand, these prohibitive impediments will be removed, and we should reasonably look for large developments in the Province during the next decade.

Among the older formations, including the Metamorphic granites, gneisses, and schists, the Palæozoic Sandstones and the Coal-bearing formation, which form the bulk of the geology of Zululand, coal, and traces of many of the economically valuable metals have been found at various times. Confining myself to the area of these rocks, over which I was enabled to make a hasty traverse, I would say, that, outside the coal-bearing formation, the areas from which metallic ores may be expected to be derived are of limited extent. Of course, I do not include in this statement, either the country to the west of Eshowe, or to the west of, or in the neighbourhood of Melmoth, areas which I have not yet had an opportunity of examining, even in a cursory way. These areas comprise the Metamorphic rocks, covering an area of about 500 square miles, to the east of Eshowe, with the lodes which occupy its faulted junction with the coal-bearing series on the north. To the north of the Makowe hills, and on towards the Lebombo, isolated hills occur, usually of a conical shape, when viewed on the line, of the strike, of the siliceous lodes which form their summits (Pl. I., Figs. 1 and 2). In some cases they are of considerable extent, and traces of metallic ores have been reported from them. They all occur traversing the basaltic rocks overlying the coal-bearing strata.

If we take the coastal belt of country, which, I term in this report, the littoral, we find, as I have stated above, that the surface rocks and alluvial deposits are of late geological age, that is to say, that they date from the Upper Cretaceous to the present day. Not having yet had an opportunity of making an examination of the coast line, I am uncertain as to the presence of rocks of Tertiary age. These newer rocks rest upon the older formations, none of which, however, except the coal-bearing rocks of the south, are likely to prove, over this area, of economic value. So that, whatever economic deposits exist, on the littoral, will occur, within no great depth of the surface. Among these newer formations, we need not expect, in this country, at least, to find

deposits, containing ores of the heavy metals or metallic oxides, which usually occur in the older formations, and among rocks which have undergone extensive metamorphism, or have been intruded by basic volcanic or plutonic rocks.

In other parts of the world, we frequently find, associated with rocks of a similar age to those forming the littoral of Zululand, deposits containing many minerals of economic value. These consist chiefly of chalk and limestones, which are used for agricultural purposes, and the production of lime and cement, lignite which forms a good local substitute for coal, clays for brick-making and pottery, marls which are often glauconitic, containing phosphates or calcareous, and used as an agricultural fertiliser, diatomaceous earths or Tripoli, which is largely used as a polishing powder, and as a non-conducting covering for steam-pipes, and in the manufacture of dynamite.

With regard to that portion of Zululand, over which I had the opportunity of making a rapid traverse, I would place before the Government the following recommendations. Beginning with the most important, from an economic point of view, I would suggest, that, the areas marked, on the accompanying geological sketch map, as being occupied by coal-bearing strata, be geologically surveyed, in a systematic and thorough manner, and maps and sections prepared on such a scale that everything could be shown clearly, and thus facilitate the development of the coal industry in Zululand. The few areas of metamorphic rocks which occur in this part of Zululand, could quite conveniently be included in the above-mentioned survey. It must be borne in mind, that it is just as essential to be able to point out the areas, under which it is impossible that coal could occur, as it is to be able to indicate the areas in which productive coal exists.

My next recommendation is, that the coastal or littoral area, be geologically examined in a thorough manner, and that the section, exposed along the coast, be taken geologically, because of the chance, as I have previously stated, of the occurrence, among these Secondary rocks, of various deposits, which might in the future, prove of economic value.

In concluding this report, I have to thank Charles Saunders, Esq., C.M.G., Chief Commissioner for Zululand, and all his officers with whom I came into contact, for their unvarying kindness, and the great assistance they rendered me. I have also to record my thanks to the following gentlemen, for assistance and information :—D. Brown, Esq.; J. Tweedie, Esq.; J. Crossly, Esq., and A. Cowley, Esq.

NOTES ON FOSSIL PLANTS

FROM THE

SAINT LUCIA BAY COALFIELD, ENSELINI RIVER,

ZULULAND.

By R. ETHERIDGE, Jun.,

Curator of the Australian Museum, Sydney, N.S.W.

NOTES ON FOSSIL PLANTS

FROM THE

SAINT LUCIA BAY COALFIELD, ENSELENI RIVER,

ZULULAND,

BY

R. ETHERIDGE, JUNR.,

Curator of the Australian Museum, Sydney, New South Wales.

The plant remains submitted to me for examination by Mr. W. Anderson, Government Geologist of Natal, are fragmentary, and in a poor state of preservation. With the exception of the *Phyllotheca* remains, they afford little more than an opportunity of attaching provisional names.

The fragments so determined are :—

GLOSSOPTERIS BROWNIANA, *Brong.*, var indica, *Bunbury.*

G. Browniana (Brong.), Tate, Quart. Journ. Geol. Soc., 1867, xxiii., p. 140, pl. 6, f. 7*a*, 7*b* (*non.* f. 5*a*, 5*b*).
G. Browniana, Feistmantel, Abhandl. K. bohm. Gesellsch. Wissensch., 1889, iii. (7), p. 43, pl. 4, f. 4 (from Tate's original).
G. Browniana, var. *indica* (Bunbury), Seward, Quart. Journ. Geol. Soc. 1897, liii., pp. 320, 321, pl. 21, f. 2 & 3.

Obs.—Four leaves, in which the venation has almost entirely disappeared, appear to correspond very closely with those figured by Mr. A. C. Seward, from the Johannesburg district, particularly his pl. 21, f. 3. One of the four specimens is five inches long from the apex to the proximal fracture, and one and a half inches wide. The mid-rib is quite distinct, tapers gradually, and reaches the apex. The venation is sufficiently preserved on these leaves to indicate that it was oblique to the mid-rib, coarser than that illustrated by Seward in his figure already

referred to, as nearly as possible the same as Tate's f. 7, representing a leaf from Cape Colony. The apices of these leaves are moderately acute.

The matrix of the specimens is a rather unctuous drab clay shale, and throughout this the *Glossopteris* leaves are thickly packed, forming what Mr. Seward has termed, in speaking of the Johannesburg fossils, a "leaf bed," although not to the same extent as some instances I have seen in our Newcastle Coal Measures. In addition to these there are two specimens of black shale from Nongoma, between the Pataza and Black Umfolosi Rivers, with leaves either of the form now under consideration, or the following variety:—

GLOSSOPTERIS BROWNIANA, *Brong.*, var. ANGUSTIFOLIA, *Brong.*

G. Browniana, Tate, *loc. cit.*, pl. 6, f. 5*a*, 5*b* (*non*, f. 7*a*, 7*b*).
G. angustifolia, Feistmantel, *loc. cit.*, p. 43, pl. 4, f, 5.
G. browniana, var. *angustifolia* (Brong.), Seward, *loc. cit.*, p. 321, pl. 21, f. 4*a*.

Obs.—Two leaves that I think may be satisfactorily referred to this variety are long and linear, but neither of them quite perfect. In one, two and a half inches long, by three-quarters of an inch wide, the acute apex is preserved, with the mid-rib extending quite to the point. The second leaf as preserved is two and three-quarter inches long, with the same width as the first.

GLOSSOPTERIS DAMUDICA, *var.* STENONEURA, *Feistmantel.*

G. damudica, var. *stenoneura*, Feistmantel, *loc. cit.*, p. 46, pl. 4, f. 7, 7*a*.

Obs.—A single large leaf, wanting its apex and base, agrees with the above figure. It is three and a quarter inches long, by two and a half inches wide. The mid-rib is strongly marked, and well raised above the surface of the leaf. The veins near the latter exhibit the peculiar elongated butterfly wing mesh, described by Feistmantel, graduating into the fine long areolœ of the central and lateral portions of each half of the leaf. The veins are never vertical.

The only difference I can distinguish between the fossil and Feistmantel's figure is a greater obliquity and upward curvature of the veins, when first leaving the mid-rib.

GLOSSOPTERIS RETIFERA, *Feistmantel.*
(Pl. 13, figs. 7 and 8).

G. retifera, Feistmantel, *loc. cit.*, p. 46, pl. 4, f. 3.

Obs.—Several specimens are here referable. At first sight the mesh is remarkably like that of *G. Tatei*,* and in fact the only difference that I can detect lies in the fact that in *G. Tatei* the veins have the

* Feistmantel, *loc. cit.*, p, 44, t. 4, f. 8.

mid-rib at a right angle, whereas in *G. retifera* they assume a considerable degree of obliquity when starting on their course. As to the mesh itself, there appears to be a fewer number of square ended areolæ in *G. retifera* than in *G. Tatei.* The areolæ are either quadrangular or hexagonal, the latter transversely so, with here and there a pentagonal areola, caused by a square or right-angled end replacing one of the pointed ends of the hexagon. Some of the areolæ approximate very closely to one of the N. S. Wales leaves figured by Feistmantel as *G. browniana.** A very similar venation is seen in the narrow strap-shaped leaves of the Indian *G. leptoneura,* Bunbury,† where again the square-ended areolæ are visible. Again in *G. elongata,* Dana,‡ of the N. S. Wales Coal Measures, the square-ended areolæ are very manifest, but they seem to be shorter and less narrow than in *G. retifera,* and the mesh as a whole is oblique. Allowing for lateral pressure, which Feistmantel's South African leaf appears to have suffered from, it and *G. elongata* are remarkably alike.

None of the leaves are perfect, but the two best measure respectively four inches long by two broad, and three and a half inches by one and three-quarters. In outline they were probably oblong-oval.

GLOSSOPTERIS, *sp. ind.*

Obs.—Three small linear leaves, although fragmentary in their venation, very closely resemble those from the Upper Coal Measures of Sydney Harbour, named by Mr. W. S. Dun, *Glossopteris acuta,*‖ in which the "nerves (are) in some cases joined by well-marked crossbars as well as the reticulations." The South African examples are basal fragments, and may spread out into larger leaves, but as nothing is known of their ultimate shape, nor form of the apices, too much stress cannot be laid on the supposed affinity.

GLOSSOPTERIS, YOUNG LEAF.

Obs.—A small leaf, three-quarters of an inch long, narrow, obtusely rounded at the apex, and with traces of a mid-rib and areolæ, may represent the young condition of one of the larger leaves. It bears a resemblance to those from S. Africa figured§ by Prof. R. Zeiller as such, particularly his fig. 2 of the plate cited below. On the other hand, it does not resemble those small leaves originally regarded¶ by Feistmantel as representing this condition, but since raised by him to specific rank, under the name *G. spathulo cordata.***

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* Palaeontographica, 1878, Sup. Bd. iii., Lief 3, Heft 2, pl. 8, f. 3.
† Quart. Journ. Geol. Soc., 1861, xvii., p. 330, pl. 9, f. 4.
‡ Wilkes' U.S. Explor. Expdn., Geol. x., 1849, p. 718, Atlas, pl. 13, f. 4.
‖ Rec. Geol. Survey, N.S. Wales, 1897, v., Pt. 2, p. 64, pl. 9, f. 4 and 5.
§ Bull. Soc. Géol. France, 1896, xxiv., ser. (3) No. 5, pl. 16, f. 1*a* and 2.
¶ Palaeontographica, 1878, Suppl. Bd. iii., Lief 3, Heft 3, pl. 12, f. 3, 5, 6.
** Mem. Geol. Survey, N.S. Wales, Pal. 3, 1890, pl. 20, f. 5, 7, 8.

ANGIOPTERIDIUM SPATHULATUM. *McClelland.*

Angiopteridium spathulatum (McClelland), Schimper, Traité Pal. Veg., 1869, I., p. 605.

Tæniopteris Daintreei (McCoy), Feistmantel, *loc. cit.*, p. 66, pl. 2, fig. 11.

Angiopteridium spathulatum, Dun. Proc. Austr. Assoc. Adv. Sci. for 1898 (1899), p. 390 (for full synonomy).

Obs.—A single example of the narrow, long, and strap-shaped leaves of that variety to which McCoy gave the name of *Tæniopteris Daintreei,* occurs with the other fossils. I believe Feistmantel was the first to record the presence of this widely distributed form in South Africa, in the Indwe and Stormberg beds in the Upper Karoo formation. The associated flora described by him was of a strictly Mesozoic facies, precisely similar to its occurrence in Australia; now we find it associated with a *Glossopteris,* or Permo-Carboniferous flora.

In 1892 I expressed the opinion* that *T. Daintreei,* McCoy, would have to be united with *Angiopteridium spathulatum,* McClelland, and since that date have not seen any reason to alter it; on the contrary, the suggestion has been adopted by Mr. W. S. Dun in the paper cited above. I pointed out the variability in the direction of the veins, and their distance apart. In the present example the veins are chiefly at right angles to the mid-rib.

PHYLLOTHECA REMAINS.

(Pl. XIII., Figs. 1—6.)

Obs.—Tate, Feistmantel, Zeiller, and Seward have all recorded fragmentary plant remains in South Africa believed to be those of this genus. Tate figured† a small portion of a flattened stem from the Beaufort beds of the Middle Karoo formation. This Feistmantel recorded‡ with a note of interrogation. On the other hand, Zeiller figures‖ a part of an articulated stem from Francis with a portion of a sheath and long filiform leaves attached. Seward gives an illustration of part of a stem exhibiting three nodes, two entire internodes, and portions of two others, also probably from the Beaufort beds, at Maggie's Mine, in the Middleburg District of the Transvaal.

I have now much pleasure in bringing forward confirmatory and better evidence of the existence of *Phyllotheca* in South Africa, as one of the results of Mr. Anderson's collecting. Amongst the latter's fossils are several portions of stems, probably hollow pith casts, preserved either as simple impressions, or as matrix casts of the stem proper, but without any traces of tissue remaining.

The first example (Pl. XIII., Fig. 2) is five inches long by half an inch wide, with a nodal constriction almost in the centre, thus affording an

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* Geol. Pal. Q'land, &c., 1892, p. 373.
† Tate, *loc. cit.*, p. 141, pl. 5, f. 6.
‡ Feistmantel, *loc. cit.*, p. 42.
‖ Bull. Soc. Géol. France, 1896, xxiv. (3), No. 5, pl. 18, f. 5, 5*a*.

internode of more than two and a half inches in length. A second (Pl. xiii., Fig. 1) fragment yields a complete internode of exactly the same length, and a third one slightly longer. Those shown on the specimen figured by Seward are much shorter, one and a quarter inches, but with a greater width. There is no trace of a branch in either of the specimens. The longitudinal, slightly convex costæ and grooves in impressions, or gentle concavities and narrow longitudinal ridges in matrix casts, as the case may be, are very distinctly marked. These convexities and concavities are broad and delicately striate, representing the broad medullary rays, and have an average width of one to one and a half millimetres. They are continuous in the same line from internode to internode, and do not alternate as in *Calamites* and *Equisetites,* as originally observed by McCoy,* a strong reason for referring these remains to *Phyllotheca*, or at any rate to that of *Schizoneura*. In the matrix casts the nodes exhibit no more than a continous, narrow raised ring, similar to another figure of Mr. Seward's,† but in the impressions a constriction is visible, indicating the place of attachment of the leaf sheaths. A similar appearance is seen in McCoy's figure of *P. Hookeri,*‡ and Bunbury's of *P. indica.*‖

The broad costæ terminate at the nodes in obtusely rounded ends, and in one well marked constriction there is a line of disconnected casts of openings, probably those of outgoing leaf-trace bundles. These are situated, not between the termini of opposite costæ, but between those of opposite groves (Pl. xiii., Fig. 3).

The leaf sheath of a *Phyllotheca* differs from that of an *Equisetum*, in that the non-coherent portion of the sheath, or collar, is divided into more or less long linear segments, or leaves, with an open and spreading habit of growth, rather than simple, persistent, short teeth, of no great length, on the upper margin of the collar. As will be seen from the accompanying illustration, the former condition prevails in the present instances (Pl. xiii., Fig. 6).

The first of the foliage specimens exhibits the leaves radiately expanded from above (Pl. xiii., Fig 4), to the number of thirty, all of them long, very narrow and linear; two of them are seven-eighths of an inch in length, and some are covered with a film of carbonaceous matter. A second example (Pl. xiii., Fig. 5) is similar although less perfect, so far as concerns its radial symmetry, but valuable, as by its means we gain a more perfect knowledge of the length of the acutely pointed leaves, viz., one and a quarter inches. A third portion is rather similar to the first, and consists of an impression of a stem fragment surrounded by that of a collar giving off six long leaves (Pl. xiii., Fig. 6), one of which is at least three inches long.

I have not succeeded in finding any illustration of a *Phyllotheca* stem-fragment, with so long internodes as those of the present specimens. The nearest is that given by Mr. Seward of his South African

* Ann. Mag. Nat. Hist., 1847, xx., p. 156.
† Fossil Plants, 1898, I., p. 285, f. 67.
‡ *Loc. cit.*, pl. 11, f. 7.
‖ Quart. Journ. Geol. Soc., 1861, xvii., pl. 11, f. 1.

*Phyllotheca,** and then Feistmantel's figure of *P. australis.*† From the close resemblance borne by the first of these to the present specimens, and the presence of the foliage, I think the latter may be fairly accepted as a *Phyllotheca*. With regard to the specimen figured by him, Mr. Seward seems to have been doubtful, for he remarks, "which might be referred to either *Phyllotheca* or *Schizoneura.*"‡ This figure, in common with one of Bunbury's, of *P. indica,*‖ and the Equisetaceous stem fragment from the Middle Karoo Formation figured by Feistmantel,§ resemble Mr. Anderson's specimens in their strongly costate nature. The stems of *P. Hookeri*, from the Newcastle Coal Measures, are described by McCoy as "coarsely sulcated and ridged longitudinally,"¶ but his figures do not convey an idea of similarity, whilst those given by Dana as *P. australis,*** although possessing a coarsely costate stem, exhibit short internodes.

In the matter of the foliage a welcome comparison can be made with the fragmentary specimen figured by Zeiller from Francis,†† in its delicate filiform leaves. Authors now appear inclined to adopt Bunbury's opinion that *P. indica* and *P. australis* are identical; Seward is emphatic on this point.‡‡ I believe the sheath in the present fossils was shallow and collar-like as described in *P. indica* by Seward,‖‖ and never attained the length said by McCoy to exist in his *P. Hookeri*—"each sheath extending from one articulation to the next."§§ Dana's conception¶¶ of *P. Australis,*, Brong., is to all intents and purposes that of *P. Hookeri*, McCoy, internodes clothed by long spreading filiform leaves, but in Feistmantel's illustration of the type species of *Phyllotheca* the leaves are much broader, apparently thicker, and enervate.*** Between these plants, and that now under description, there is this resemblance, that in the latter the foliage is longer than the internodes surrounded by it, the internodes being two and a half inches, or more, and the leaves at least three inches long (Pl. xiii., Fig. 6), whilst in *P. australis,* and *P. Hookeri* the leaves of one sheath similarly extend well beyond the node of that above it. In *P. deliquescens,* Goppert,††† are also long and linear leaves, although fewer in number in a whorl.

To sum up, we see in the *Phyllotheca* collected by Mr. Anderson the remains of a plant that are distinguished by *(a)* the length of its

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* Quart. Journ. Geol. Soc., 1897, liii., pl. 24, f. 1; Fossil Plants, 1898, I., p. 285, f. 67.
† Palaeontographica, Suppl. Bd. iii., Lief. 3, Heft. 3, 1878, pl. 15, f. 2.
‡ Fossil Plants, 1898, I., p. 284.
‖ Quart. Journ. Geol. Soc., 1861, xvii., pl. 11, f. 1.
§ Feistmantel, *loc. cit.*, pl. 3, f. 9.
¶ Ann. Mag. Nat. Hist., 1847, xx., p. 157.
** Wilkes' U.S. Explor. Exped., Geol. x., 1849, pl. 13, f. 6. In speaking of *P. australis*, Mr. Seward makes a mistake, evidently unintentional—he says:—"*P. australis* as figured by McCoy" (Fossil Plants, 1898, I., p. 288). I am not aware that this author ever figured *P. australis.*
†† Bull. Soc. Géol. France, 1896, xxiv. (3), No. 5, pl. 18, f. 5, 5*a*.
‡‡ Fossil Plants, 1898, I., p. 288.
‖‖ *Ibid*, p. 288.
§§ Ann. Mag. Nat. Hist., 1847, xx., p. 157, pl. 11, f. 4 and 5.
¶¶ Wilkes' U.S. Explor. Exped., Geol. x., 1849, p. 718, pl. 13, f. 6.
*** Palaeontographica, Suppl. Bd. iii., Leif. 3, Heft. 2, pl. 6, f. 3, pl. 7, f. 2. Dana makes no mention of the presence or absence of a nerve in the leaves of *P. australis*, but Zigno states definitely that they are enervate (Flora Foss. Ool., I., p. 55).
††† Schmalhausen, Mém. Acad. Imp. Sci. St. Pétersburg, 1879, xxvii. (7), No. 4, pl. 10.

internodes; *(b)* size of the longitudinal costæ of the stem; *(c)* length and filiform outline of the leaves, with an expanded and open manner of growth; and *(d)* possibly combined with a short and low collar. The two first features we see repeated both in Australian and Asiatic forms. That the stem fragments and foliage I have described belong to one and the same plant I have assumed, because they are associated on the same matrix specimens, to the exclusion of any other remains. If it be desirable to distinguish these South African fragments by a name, I do not think a more fitting course can be adopted than by associating with them the name of the eminent French Palæobotanist and Engineer, —Prof. R. Zeiller—as *Phyllotheca Zeilleri,* who was certainly the first to indicate, with any degree of certainty, the presence of *Phyllotheca* in that geographical area.

The only other organisms observed in company with the plant fragments are an *Estheria*, and a few fish scales, apparently Ganoid. The former resembles:—

ESTHERIA GREYII, *Jones.*

Estheria (of a new species), Jones. Quart. Journ. Geol. Soc., 1871, xxvii., p. 50.

Estheria, Greyii, Jones, Geol. Mag., 1878., v. (2), p. 100, pl. 3, f. 1.

Obs.—A single cast of a small bivalve shell, without test, I take to be this species, although the antero-dorsal angle is not so sharply marked, but more rounded; still, in so delicate an organism as the valves of an *Estheria,* exact resemblance can hardly be expected. The concentric rugæ are as well marked as in Prof. Rupert Jones' figure, but no sculptured ornament or radiating lines are preserved.

In its more rounded outline it bears some resemblance to a fossil, termed by Mr. Daniel Sharpe *Cyrena,* sp.,* from Graaf Reinet, in the Beaufort beds of the Middle Karoo formation.

The aspect of these fossils, omitting the *Estheria* and *Angiopteridium,* is to me, unquestionably, that of our Upper or Newcastle Coal Measures, in which the remains of *Glossopteris* and *Phyllotheca* are remarkably abundant. This series forms the uppermost member of our great Permo-Carboniferous System, but so far no Tæniopterid has been found therein.

Mr. Seward, speaking of the range of *Phyllotheca,* says† it "is often spoken of as a characteristic member of the *Glossopteris* Flora of the Southern Hemisphere, and its geological age is usually considered to be Mesozoic rather than Palæozoic." With us, *Phyllotheca,* although possibly occurring in the overlying Mesozoic, attains its greatest development in those beds we are accustomed to place at the top of the Palæozoic series, the Newcastle Coal Measures. Prof. Zeiller again,

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* Trans. Geol. Soc., vii. (2), pl. 28, f. 7.
† Fossil Plants, 1898, I., p. 291.
‡ Bull. Soc. Géol. France, 1896, xxiv. (3), No. 7, p. 483.

in referring to the occurrence of *Annularia, Phyllotheca, Glossopteris,* and *Nœggerathiopsis* in our Greta or Lower Coal Measures, remarks that at the top of the series,* in the Hawkesbury or Wianamatta beds, &c., the secondary type, "se multiplient," but *Gangamopteris* and *Nœggerathiopsis* have disappeared. I am not quite clear whether Zeiller infers that the Hawkesbury and Wianamatta beds are portions of the same great series of strata as the Greta Coal Measures, or not, and criticism may therefore be uncalled for. If, on the other hand, such an inference is intended, then it is quite at variance with the accepted views of New South Wales Geologists.

PLATE XIII.

PHYLLOTHECA ZEILLERI, *Eth, fil.*

Fig. 1.—Portion of a stem, exhibiting a node, a complete internode, and portion of another.
„ 2.—Portion of another stem, exhibiting a node and portions of two internodes.
„ 3.—Small portion of a stem, with a node and portions of two internodes. On the impression of the node are visible casts of the orifices of outgoing leaf-trace bundles. x 2.
„ 4.—Impression of a complete whorl of linear acicular leaves.
„ 5—A less perfect but similar specimen.
„ 6.—Portion of a small stem and collar, with six leaves radiating therefrom. x 2.

GLOSSOPTERIS RETIFERA, *Feistmantel.*

Fig. 7.—Portion of a frond exhibiting quadrangular, pentagonal and hexagonal areolæ.
„ 8.—Some of the areolæ enlarged.

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*i.e., above the Newcastle or Upper Coal Measures.

REPORT ON THE GEOLOGY

OF THE

LOWER TUGELA DISTRICT, VICTORIA COUNTY, NATAL.

REPORT ON THE GEOLOGY OF THE LOWER TUGELA DISTRICT, VICTORIA COUNTY, NATAL.

INTRODUCTION.

The area referred to in this report, embraces the northern portion of the County of Victoria, and is bounded by the lower part of the Tugela River, the sea coast, the Tongaat river, and the Mapumulu valley. The portion geologically mapped, includes an area of 500 square miles, part of which I mapped from February to May, 1899, while the remainder occupied my time, from July to the end of November, 1900. I chose this district in which to commence the systematic geological mapping of the Colony, because, the topographical survey having been begun here the year before, the Government Surveyor, Mr. Hammar, had prepared a topographical map on a scale of one inch to the mile, and therefore this map was available, upon which the geological features could be delineated.

The only town in the district is Stanger, situated about three miles to the north of the Umvoti river. In its neighbourhood, the chief industries are the growing of sugar, and the manufacture of tea. In the early days, this portion of the Colony was largely used for the production of cotton, but now its place has been taken by sugar and tea. There is no mining of any kind now going on in the district, but some years ago a good deal of prospecting work was done on the farm belonging to Mr. Ritchie, on the Umhlali river. In this locality, remarkably good specimens of gold-bearing quartz were met with, but the reefs which occurred in the Palæozoic Sandstones, in all cases pinched out before they attained any depth. Fairly rich alluvial was also got, which had been thrown from these reefs.

The following geological formations are represented in the area mapped:

Metamorphic Rocks (including Granites, Gneisses and Schists).
Palæozoic Sandstones (The Table Mountain Sandstones of Sutherland), (The Witteberg & Zuurberg Beds of Dunn).
Dwyka Conglomerate.
Ecca Shales (including the Coal-bearing Series).
Pleistocene and Recent Alluvials (including the sand-dunes of the coast, and the river alluvials).

In a general way, the outcrops of each of these formations, have a somewhat linear disposition, approximately parallel to the coast, with the exception of the last, which naturally has an almost universal distribution. The Metamorphic rocks and the Palæozoic sandstones, form portions of the belt which outcrops from the Tugela river, through the Mapumulu and Inanda Divisions southwards, to near the mouth of the St. John's

river. The Dwyka Conglomerate and the Ecca Shales, may be said to be also part of that belt, while the coal-bearing portion of the latter has, to a certain extent, a restricted and local occurrence. Between the Metamorphic rocks and the Palæozoic Sandstones, there is a well marked unconformity, and this is also the case between the latter formation, and the Dwyka Conglomerate. The Ecca Shales, with their included coal-bearing rocks, seem here at least, to be slightly unconformable with the Dwyka Conglomerate. The coal-bearing series is entirely confined to a narrow belt on the coast, south of the mouth of the Umvoti river. The Pleistocene and Recent Sand dunes, are likewise confined to the coast.

TOPOGRAPHY.

As this area includes country rising from the sea-level to a height of over 3,000 feet, its topography is necessarily of a very varied description. It is drained by the lower portions of the Tugela, Umvoti, and Tongaat rivers, and embraces the basins of the Nonoti, Sinkwazi, and Umhlali rivers. All of these rivers are usually permanently-running streams, although, during last season, which was excessively dry, they were lower than they have ever previously been known to be. The trend of the river valleys is in a more or less east and west direction. Unfortunately, they have, in all cases, sand-bars at their points of exit into the sea, so that none of them can be used as waterways. The river valleys are, as a rule, worn to a considerable depth, but are usually very narrow and contain few alluvial flats of any extent. The most deeply-eroded portions of the valleys are near their sources, particularly in the case of the Umhlali river, whose sources have formed the deep valleys to the west of the Glendale police camp. For the greater part of their course, with the exception of the Umvoti and Tugela, the river valleys have been eroded through the horizontally-bedded Palæozoic Sandstones; and, as a natural consequence, precipitous cliffs are of frequent occurrence. This is particularly the case in the Umvoti river, to the south of Ocean Lodge, and to the east of the Sikeni Trig. Station; while, in the upper reaches of its tributary, the Isani river, which drains the Glendale plateau, precipitously-sided gorges and almost perpendicular waterfalls have been formed during the erosion of the valley through which it flows.

The littoral consists, generally, of comparatively low undulating country which rises gradually into the plateau of the uplands. Ranged along the shore-line, just above high-water mark, are a series of sand dunes, rising in places to a considerable height, and frequently covered with dense jungle. A mass of such vegetation occurs on the south side of the mouth of the Tugela river. In the Umhlali district the whole coastal belt used to be covered with small timber and dense scrub, and, even yet, large areas of jungle land exist; but this is gradually being cleared off by the advance of the Coolie occupation of the land. Much of the littoral, particularly near the coast-line, is covered with wind-blown sand, and over these areas rock outcrops are of rare occurrence, as the

small streams which flow over the sand-covered country seldom cause the erosion of the sands to a sufficient depth to expose the underlying rocks. In the area occupied by the coal-bearing series, in the Umhlali district, this is particularly the case, so much so that, if it were not for the coast sections, it would be extremely difficult to obtain a knowledge of these beds.

The sand dunes consist almost entirely of wind-blown sand, which, locally, almost covers the country for some miles inland. In many localities this sand is a bright chocolate colour, somewhat similar to that produced in soils by the degradation of basic volcanic rocks, such as basalts, diorites, &c.

The uplands consist of a plateau formed of the horizontally-bedded Palæozoic Sandstones, and have an average elevation of about 2,000 feet above sea-level. This elevation is attained from 12 to 18 miles from the sea-coast. Further inland, the country dips suddenly over the precipitous edge of the sandstone outcrops on to the lower granitic country which forms the valleys of the Umvoti and Insuzi rivers. A feature of this high portion of the district is that, as a rule, the streams have cut their way deeply into the sandstones, producing narrow, precipitous gorges. The plateau country is usually open and treeless, well watered, owing to the frequent occurrence of springs, and forms good grazing land; but, since the rinderpest, some years ago, few cattle or sheep are to be seen anywhere.

Pleistocene and Recent.

In this district, the occurrences of the more recent Quaternary deposits, are of a limited extent, except near the coast line, where comparatively large areas are covered with wind-blown sands. Inland, deposits of river alluvials are of rare occurrence, and as a rule, only small local patches are met with. The largest of these is probably the alluvial flat, near the mouth of the Umvoti river, while others occur of small area, as at Riet Valley, and close to Lyle's house. near the mouth of the Tugela. The large flat known as Compensation Flat, contains areas of Pleistocene alluvials, particularly in the neighbourhood of the water channels; but over a very large portion of it, the rocks either crop out at the surface, or are at a very slight depth under the sub-soils.

In the valleys of the main rivers and creeks, there is little alluvial deposited, owing to the depth to which they have been cut, and the rapidity of the river flow, when in flood. Even in the Glendale Valley, formed by the erosion of the Umvoti river, there are comparatively few alluvial flats of any extent, and it is exceedingly rare, to find evidences, in the presence of high-level gravels, &c., of ancient river levels in any of the valleys. For this reason, and owing to the rapidity and completeness of the weathering and disintegration of the surface deposits, there are few opportunities of obtaining a knowledge of the Pleistocene fauna and flora of this part of the country, as there are here few deposits of that age left, which are favourable for the preservation of their fossil remains.

On the other hand, the Pleistocene and Recent coast deposits, consisting of wind-blown sand, which forms the ridges and hills immediately bordering high water mark, are of considerable extent at every point along the coast line. In some cases, for instance, immediately south of the mouth of the Umvoti river, these sandy deposits cover the whole country, as far inland as the railway line at Umvoti Station, while in other places its width from the sea shore is very limited indeed. Locally, it attains a thickness of a few hundred feet. A good instance of this occurs about a mile down the coast from the Umvoti river, where the sand hill has been denuded into a circular hollow, with almost precipitous sides, and of a considerable extent. This is rather a remarkable place, and is a splendid example of the effects of denudation, resulting from the presence of a spring or springs, emerging from under the loose sandy Pleistocene deposits, which rest upon the horizontal Ecca beds below. The creek which drains this hollow is always a strong running stream, and emerges from it, by a narrow gully of no great length, eroded to a slight depth in the Ecca shales and sandstones. Almost the entire inner surface of the hollow is covered with heavy timber, and dense undergrowth of low scrub. Except by wading up the drainage creek, there is only one entrance-track into the hollow by a steep descent on the northern side. The sand, as exposed in the walls of the hollow, is of a gritty and ferruginous character, and so far as I was enabled to discover there are no pebbles or boulders, and no deposits of shells or other organic remains.

At various other points along the coast, however, in the sections of the sand dunes, exposed on their seaward aspect, deposits of shells, burnt wood, &c., frequently are to be seen, while in sheltered localities quantities of well water-worn pieces of pumice are often met with. The frequency of the occurrence of the latter, and the comparatively fresh state of the pumice is interesting. It is certainly not a local product; and, although pieces are often found at a much higher level than the present high-water mark, there are no local deposits out of which they may have been washed. They are, evidently, derelicts from the ocean; but in what part of the earth the volcanic eruptions occurred which produced them we have no local proof. On the African continent the nearest active volcanoes occur far to the north, and long distances from the east coast; and we have no knowledge of the presence on any part of our coast of any geologically-recent volcanic lavas from which they might have been derived. It is just possible that they are some of the distant relics of the eruption of Krakatoa, which took place some years ago in the Malay Archipelago, and which have floated across the Indian Ocean to our shores; or the other alternative that presents itself is, that they have come from eruptions in the actively volcanic area of the Antarctic regions.

With regard to the shelly deposits, with burnt wood, &c., there can be no doubt that they have chiefly been formed by human agency. There are, probably, exceptions, particularly in the neighbourhood of the openings of the creeks and rivers into the sea, where layers of pebbles exist, accompanied by layers of broken shells, at a higher level than the

present sea-level. These are, however, undoubtedly the remains either of old raised beaches or of ancient high river gravels, more probably, from their position, the latter. In none of these deposits have I been able to detect anything in the way of fossil animals, or the implements of man.

The first-mentioned shelly deposits, which are really analogous to the kitchen middens occurring on the coasts of all the continents, are very numerous, and are present at all levels in the sand-dunes. They are even now being formed by the present-day natives, who go in family parties to the beach at low tides and gorge themselves on the mussel. Their method of procedure is given above. As a rule, the extent of the individual deposit is not very large. They chiefly consist of large mussel (*Mytilus perna, L.*) and oysters (*Ostrea prismatica* Gray), with the usual accompaniment of small gasteropods, which, however, were quite evidently not used for food. In one kitchen midden that I opened, near the mouth of the Sinkquasi river, large quantities of the broken fragments of large earthenware pots occurred among the shells which were the large mussel, the only edible shell-fish, with small gasteropods and limpets. The deposit occurred about 20 feet above the level of the lagoon at the mouth of the river, which is a considerable height above high water-level. It cropped out in a sandy cliff, now covered with undergrowth, and it is overlaid by more than 20 feet of sand. Its lateral extent is not great, and, in thickness at the point I worked it, it averages about two feet. A few fractured pieces of quartzite occurred among the shells which exhibited somewhat chipped surfaces, but they are so crude and irregular, and show so little evidences of any attempt at a distinct form, that I would hesitate to identify them as human implements. No bones of any animal were found in this deposit. The broken earthenware fragments show a remarkable variety of ornamentation, particularly round the neck of the vessel. Much of this ornament consists of straight lines, evidently made with the finger nail, although, in certain cases, where the lines were prolonged to any extent, as encircling the whole vessel, they were evidently made with the aid of some instrument. The shells were kindly identified for me by Mr. Burnup, who found them all to belong to species now living.

Coal-bearing Series of the Eccas.

The Coal-bearing series of the Eccas, shown upon the south-eastern portion of the map (Pls. xix.), outcrop between the Umvoti and Tongaat rivers, and between the coast and the lower foot-hills of the inland plateau, where they are separated from the Palæozoic Sandstones, by the outcrop of the Dwyka Conglomerate. They have, as a rule, a very low dip, rarely more than 20°, but usually not over 10°. The only exception to this, is a set of shales, which crop out about half-a-mile north of Mr. Leslie's house Umhlali, where they have a high dip of 30° towards S 60°W. In the creek below, towards the railway, a coarse gritty sandstone is exposed, dipping 15° towards E. 25°S. On the flat on which the Umhlali Police Camp is situated, a large intrusive basaltic sill outcrops.

The intrusion of this rock may have had something to do with the tilting of the shales to so high an angle, but the probability is that there is also local faulting.

This coal-bearing series is merely the extension northwards, of the coal-bearing rocks which outcrop below Verulam, nearly to the Umgeni river. The beds are well exposed between tide marks, on the sea shore. Inland, however, in the neighbourhood of Umhlali, particularly on the timber clad area, between the sea coast and the watershed of the coastal creeks, actual outcrops of these beds are not at all abundant. Occasionally a few feet of black shale, exposed in the bed of a creek or donga, is all one sees of the actual strata. As a rule, wherever volcanic rocks exist near the surface, evidence of their presence is generally to be found, in the characteristic chocolate colour their decomposition gives to the soils. In a few localities, a very fine grained pyritic rock, called felsite in the records of the bores in the Commissioner of Mines reports, occurs among this series. They are probably intrusive and for this reason, they, like the intrusive sills of basalt, have no value, as a guide to the correlation of the various exposures of the series. Basaltic intrusions, both in the form of dykes and sills, are of common occurrence. Faulting is rare, and when it does occur, the displacements are never very great. Many of the shales are very carbonaceous, while others are chiefly micaceous. The sandstones, as a rule, are coarse grained and of a friable character. Very few outcrops of coal occur, and only in one place, in the shales associated with the lower coal at Morewood Cove, are fossils present.

The succession of the rocks above the unconformity between the Palæozoic Sandstones and the Dwyka Conglomerate, is as follows :—

(1) The Dwyka Conglomerate, which is of irregular thickness.

(2) A series of black carbonaceous, thin bedded shales, showing no trace of fossil remains. There is probably a slight unconformity between (1) and (2), because frequently we see in this district patches of shale, which have undoubtedly been deposited in the irregular hollows, in the glacial conglomerate. The upper portion of this series, consists sometimes of micaceous and light grey coloured sandy shales. They are present overlying the black shales, a little below the mouth of the Umvoti river, although they are not present in the sections seen between Compensation Flat and the Tongaat river. These are also unfossiliferous.

(3) The coal-bearing series, consisting of sandstones, alternating with a series of micaceous, sandy carbonaceous shales, including thin coal-seams. This series is best developed between the Umhlali and Tongaat rivers, for a distance of about three miles inland. The black shales, associated with the coals, are very fossiliferous, chiefly plants, such as many species of *Glossopteris*, *Phyllotheca*, &c. In some of the sandstones, large pieces of fossil wood occur.

The coast section from the Tugela mouth to the Tongaat river, although not absolutely complete, in that, occasionally, long stretches of sand cover up the section in places, is of interest and importance in aiding the elucidation of the sequence of beds, from the Dwyka Conglomerate up to the coal-bearing series of the Eccas. The section is given as Pls. xvi. and xvii.

From the Tugela to the Umvoti rivers, the areas occupied by the dark coloured shales, which overlie the Dwyka Conglomerate, are very limited, in comparison with those occupied by outcrops of the Dwyka. This applies chiefly to the inland area, as far as the foot-hills, where the Palæozoic Sandstone commences. In fact, this sandstone outcrop comes down close to Stanger, and also occurs over a considerable area in the lower part of the Sinkwazi valley, thus leaving only a small area in the neighbourhood of the Inyatikasi Hill, and at the mouth of the Tugela river, where these shales occur at the surface. They are carbonaceous to a certain extent, but they undoubtedly belong to the black shales, immediately overlying the Glacial Conglomerate, and not to the higher coal-bearing series, and therefore, there is, to my mind, no likelihood of payable coal being discovered over this part of the district.

The area occupied by the Ecca Shales, between the Umvoti and Umhlali rivers is included, between the railway line and the coast. On the block known as Umhlali Wagon Drift, the Palæozoic Sandstones come to the surface, thus restricting the occurrence of the shales overlying the Dwyka Conglomerate to the block known as Addington, with an extension as far as the Umhlali river railway station. About half a mile above the mouth of the Isibeni Creek, on this block, black carbonaceous shales crop out containing very imperfect traces of plant remains, and bearing a striking resemblance to the fossiliferous black shales associated with the coal at Morewood Cove, Umhlali beach. Immediately below the mouth of the Umvoti river, in the coast section, light coloured and sandy shales occur, associated with the carbonaceous shales. They are, here, much intruded by both coarse and fine-grained basaltic rocks. Towards the mouth of the Isibeni Creek thick beded sandstones and grits occur, with interbedded black shales, in which I was unable to detect any sign of fossils. Between this and the mouth of the Umhlali river, a very coarse-grained volcanic rock outcrops almost continuously along the beach, while inland, a little over a mile, two large volcanic sills occur, associated with the Palæozoic Sandstones.

A thin, poor, seam of dirty coal attracted considerable attention some years ago, as a probable source of, or a good indication of, the presence of payable coal on this block, but the close proximity of the Dwyka Conglomerate outcrop on the north-west, and the outcrop of the Palæozoic Sandstones on Umhlali Wagon Drift to the south-west, and also on the Umvoti river, would, to my mind, preclude the possibility of payable coal of good quality occurring over this area, because these boundaries limit the area of the basin, and prove the small thickness of Ecca Shales which are present here, overlying the Dwyka Conglomerate.

Over the area between the Tongaat and Umhlali rivers, that portion of the Ecca Series, which contains coal, is developed. We have,

therefore, in this portion of the district, the highest beds, of any, which belong to the Ecca Series, in the country surveyed. For about four miles above the Tongaat mouth, a coarse-grained basaltic rock crops out along the coast. It is a very similar rock to that, mentioned as occurring, immediately to the north of the Umhlali river mouth. From this point, on to the Umhlali, a good coast section of the coal-bearing Ecca Series occurs (Pl. xvi.). The northern road may be taken as the western limit of the occurrence of these coal-bearing rocks. A thin coal-seam was struck in a bore put down close to Compensation Flat. Near the northern boundary of block E, about two miles above the mouth of the Tongaat river, the outcrop of a thin, inferior coal-seam occurs. In the coast section, at Morewood Cove, a fourteen-inch seam of inferior bituminous coal occurs, while some distance to the south, another small coal-seam crops out in the cliff on block 60. With these few exceptions, I have come across no other outcrops of coal, in this district.

In the last-mentioned position, on block 60, we have, I think, the highest set of beds in the coal-bearing series of the district, and, as seen in the section (Pl. xvi.), two thin coal-seams occur among them. To the south, the whole series is cut off by the intrusion of a coarse-grained basalt, as far as the mouth of the Tongaat river, where the sedimentary rocks again begin to crop out. At Morewood Cove, the beds containing the lower coal-seam form a small anticlinal fold, which to the north is followed by a syncline, and then another small anticline of the same beds. From this point on to the Umhlali river mouth, the series have undergone slight displacement, chiefly by faulting, and the intrusion of volcanic dykes. None of these beds are fossiliferous, except the shales immediately overlying the lower coal-seam at Morewood Cove, and a thick-bedded yellow sandstone (Pl. ix., Figs. 1 and 2), which crops out in the cliff about two miles south of the Umhlali river mouth. The latter contains, often, large waterworn pieces of fossil-wood. There is, therefore, no palæontological evidence, to show the exact correlation to these displaced beds with those at Morewood Cove. In the Cliff below the houses on block 64, sandstones with coaly shales occur (Pl. x., Fig. 1). From the general succession of the beds, they seem to me, to represent that part of the series in which the lower coal-seam occurs at Morewood Bay, and I think that it is more than probable that we have those beds frequently repeated, in this part of the section, until at the Umhlali mouth, we get the lowest series of the Ecca Shales. Some little distance up the river the Palæozoic sandstones outcrop, thus cutting the Ecca Series off toward the north.

A number of bores have been put down in the district of Umhlali, through portions of the coal-bearing division of the Ecca Series. One was put down close to the northern side of the mouth of the creek which flows through block 61. It reached 132 feet and was stopped, in what was described as decomposed greenstone, after passing through sandstone 9 feet, greenstone 15 feet, sandstone 39 feet 6 inches, felsite 23 feet, sandstone 48 feet 3 inches, greenstone 6 feet 10 inches. The so-called felsite, struck at about 60 feet from the surface, is undoubtedly

the same rock which outcrops on the shore at the mouth of the creek. It is here seen to intrude the sandstone. All the beds dip inland, and, therefore, this bore has merely passed through the rocks which are exposed on the surface.

Another bore was put down about half-a-mile inland from the outcrop of the lower coal at Morewood Cove, but no information is obtainable as to what depth the bore attained, nor what rocks were passed through.

On the south-east side of the railway line, close to the creek to the south of Mr. Knox's house, on the main road, near Umhlali, over 360 feet of boring has been done, passing through chiefly sandstones and so-called felsites. No coal or shales were struck in this bore.

A bore was also put down to the east of Compensation Flat, in which a seam of coal, 16 inches thick, was struck.

Recently boring operations were started by Mr. Keith Fraser, close to the railway line, about three miles north of the Tongaat river.

The information obtained from these bores is very limited, particularly in reference to the main object for which they were put down, that object being the proving or disproving some distance inland the presence, thickness, and quality of the coal-seams exposed in the cliffs at Umhali beach. I have stated, in an earlier portion of this report, why the usefulness of bores is curtailed by not having the cores properly preserved, and the various strata passed through named by a competent authority and recorded, with the exact site. I would also point out that it is an utter waste of time and money to put bores down in a haphazard manner without being able to say, for geological reasons, why the particular sites were chosen. This coalfield is a case in point. Notwithstanding the advice given by Mr. North, in 1881, as to the position in which it would be best to prospect for the coal, and prove whether it existed of the necessary thickness and quality, no efforts were made, except in the immediate vicinity of the outcrops, where it is very improbable that the necessary bettering of the seam would take place.

The fossil plants from the coal-bearing beds of St. Lucia coal-field, bear a strong resemblance to those which I obtained, in the shales associated with the lower coal at Morewood Cove. They chiefly consist of various species of *Glossopteris,* together with abundant remains of the crushed stems of *Phyllotheca*. I have not yet had these remains identified specifically, but from the general facies, they would seem to be the same in character as those of St. Lucia Coal-field, in Zululand. The stratigraphical evidence certainly points to the same conclusion, and there is little doubt in my mind, that they will prove to be of Ecca age, and, like the Zululand Eccas, belong to the Permo-Carboniferous period. The development of the coal-bearing portion of the Ecca Series is not so great in this locality, as is the case in the various coal-fields of Zululand. Not only is the area of outcrop more circumscribed, than in Umlalaas or in St. Lucia coal-fields, but the actual thickness of strata exposed, is very much less. At Umhlali, we have the lower portion of the coal-bearing Ecca series,

and it is extremely likely that the upper part of the series, exists on the ocean floor to the eastward. As we do not know sufficient about the sequence of beds, forming the coal-bearing Eccas of Zululand, we cannot correlate the thin coals occurring in the Umhlali district, with the coals of the Zululand coal-fields, and therefore, we cannot say, whether the coals in Zululand occur on the same horizon as the Umhlali coals, or whether they exist in the upper portion of the series, which are not exposed at the latter place. It is, therefore, impossible to say whether the beds forming the sea floor, and occupying a position geologically above the coals at Umhlali beach, contain coals or not.

At their exposure on the coast, the two seams are very uniform in thickness, while the coal struck at Compensation Flat, was practically the same thickness. If we could identify the Compensation Flat coal, with either of the seams on the coast, this uniformity of thickness would augur badly against the possibility of the occurrence, between the coast and Compensation Flat, of an increased thickness in the coal-seam. It is quite possible that the seam, occurring three miles inland, is one or other of the two exposed on the coast. I quite agree with Mr. North,* that to prove this point, and also whether the seam thickens between the coast and Compensation Flat, the best position in which to bore, would be either on block 54 or 56.

So far as my examination went, I consider it very doubtful indeed, that payable coal will be discovered anywhere between the Tongaat and Tugela rivers. The only possible position, in the area above mentioned, immediately to the south of Umhlali. When that portion of the coal-bearing series, which occurs south of the Umhlali river, has been examined and mapped geologically, a much more complete idea can be formed of the proper sequence of the beds, together with greater certainty as to the local occurrence of payable coal.

Dwyka Conglomerate.

This formation is well developed over a large part of this area, particularly in a north and south belt a few miles from the coast. At Bond's Drift, on the Tugela river, and in the neighbourhood to the south of it, it outcrops over a considerable area and exhibits the typical characters of this formation. When fresh the matrix is of a dark-blue colour, and contains the usual collection of angular, sub-angular, and rounded pebbles and boulders of all sizes, chiefly consisting of metamorphic and crystalline rocks. Here the primary weathering of this rock is largely spheroidal, while, subsequently, the matrix breaks up into small scales, which ultimately releases the enclosed boulders and pebbles. Locally, in various parts of the district, the matrix assumes a light-yellow colour, which is probably due to the oxidation of the ferruginous material in the base. This can be seen in certain places in the sections exposed along the coast-line. In no part of the district have I seen any striated, polished, or flattened pebbles or boulders, but

*Report upon the coalfields of Klip River, Weenen, Umvoti, and Victoria Counties, by F. W. North. pp. 48. London, 1881.

in many places glacially-striated pavements of the underlying Palæozoic Sandstones are of frequent occurrence. Where the Dwyka Conglomerate has but recently been denuded off the surface sandstone, the striæ are very distinct and well marked.

The position in which the best examples of the glacially-striated rock surfaces occur are as follows :—

1. On block 38, north of Twatyini Trig. Station, in the road cutting, south of the crossing of the Nonoti river.
2. On block 15, about a mile-and-a-half west of Sranger. (Pl. vii., Fig. 1.)
3. On block 8, west of Groutville. (Pl. vi., Fig. 1.)
4. On block, Chaka's Kraal, about one mile east of Mr. Ritchie's house.
5. On block, Chaka's Kraal, about one mile west of Groutville Trig. Station, near northern boundary.
6. On block, Compensation, close to its western boundary.
7. On block 4, about a mile north of Tongaat river, near its western boundary.

These glaciated pavements all occur in close proximity to the outcrop of the edge of the Dwyka Conglomerate, where it has recently been removed by denudation. The surfaces are usually flat, and correspond to the bedding of the sandstones, which are practically horizontal. I have not observed any *roches moutonnées*, nor glacially-striated vertical or highly inclined surfaces. In the majority of cases the striated surfaces are composed of coarse-grained sandstones and grits, but the rock of No. 6, on Compensation, is a conglomerate. The general trend of the striae varies from a few degrees south of west to a few degrees north of west. As a rule, they are well marked, but never very deep, usually wider than deep. The edges are rough, and not sharply defined. This is, however, probably due to subsequent weathering. The surfaces show very little smoothing or polishing, and are usually coated with ferruginous matter, like the majority of the joints in this formation. Although I have carefully looked over the Dwyka Conglomerate *in situ*, and its weathered *debris*, in the immediate vicinity of these striated pavements, I have failed to discover any striated, polished, or smooth pebbles or boulders, leaving us with the fact, that, over this area, at least, the only local evidence of glacial conditions of climate, during the deposition of this formation, is in the glaciation of the sandstone floor, upon which the conglomerate was laid down. Of course, the general characters and the composition of the typical glacial Dwyka Conglomerate are here; and its stratigraphical position, as regards the overlying Ecca Series, is indisputable. The glaciated pavements are, in every case, composed of Palæozoic Sandstones. No surfaces of granite or metamorphic rocks have been observed carrying striæ. This is probably due to the fact that the denudation, which has exposed the Metamorphic rocks to view, was long subsequent to the deposition of the Dwyka Conglomerate. The probability is, that during the formation of the Dwyka Conglomerate, that belt of country, consisting of Palæozoic

Sandstones and Metamorphic rocks, which stretches from the Mapumulu and Krantz Kop districts, through Natal, to the south-east coast, formed an elevated land surface, covered with the land ice which produced the *debris* now forming the Conglomerate.

There is evidence in this district of the fact, that, during the formation of the Dwyka Conglomerate, particularly in its upper portions, areas occur in the conglomerate, where there are neither boulders nor pebbles, but well stratified shales. These shales seem to be, to all appearances, conformable with those of the Ecca Series above, but they must have been deposited in the hollows of the irregular surface of the glacial debris, and therefore point to an unconformity. That it is not of any great extent, is shown by the similarity of sediment of the shales, and the matrix of the Dwyka Conglomerate. In a paper lately read by Messrs. Rodgers and Schwarz, of the Geological Commission, Cape Colony, before the South African Philosophical Society, they contend that, in the districts, at least, from which they show figures of the glaciated surfaces under the Dwyka Conglomerate, that deposit represents ancient morains and tills, in fact, that it is the product of land ice, and is really a boulder clay. This is probably true of the conglomerate, over many areas, and likely enough explains, to some extent, the great and often perplexing differences of level, at which, the deposit exists, which would otherwise be inexplicable, if the Dwyka had been wholly a fluviatile deposit.

An article* occurs in the Scottish Geographical Magazine, for February, 1901, "On a former Ice Age in South Africa," in which an extract is given from the Report of the Geological Survey of Cape Colony. In this report, Professor Corstorphine gives a *resumé* of the more important points touched upon by previous writers, in connection with the origin, &c., of the Dwyka Conglomerate, and incorporates the work and discoveries made during the last few years, by Messrs. Rogers and Schwarz, in carrying out the field work of the geological survey.

Professor Corstorphine calls attention to the fact, that along the northern outcrop of the Dwyka Conglomerate in Cape Colony, there is always a distinct unconformity between it and the rocks upon which it rests; while along the southern outcrop it invariably rests conformably on the Witteberg quartzites. The conclusion which he draws from this difference is, that the conglomerate of the northern outcrop, is the result of terrestrial glaciation; while the southern rock "is a sediment" "formed under a probably inland water, into which there floated the" "icebergs calved from the front of the glacier or glaciers on the" "northern shore. These carried with them the glacial debris, and the" "striated boulders which now form the conspicuous feature in, and," "reveal the story of the southern conglomerate."† This is an important advance in reference to the investigations, as to the origin and history of this interesting deposit. It is the first time that use has been made, of the fact, that the unconformity of the northern rock, had a most important significance, as bearing upon the origin of the deposit.

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* The Scottish Geographical Magazine, Vol. XVII., No. 2, pp. 57. 1901.
† Ibid, pp. 73.

In the eastern portion of Natal, we have an east and a west outcrop of Dwyka Conglomerate, separated from each other by outcrops of granites, gneisses, and schists, and the Palæozoic Sandstones. This forms the area I have previously referred to, as having been an elevated ice-clad land surface, during the formation of the Dwyka Conglomerate. At both outcrops, the conglomerate rests unconformably, on the Palæozoic Sandstones. It is rare to find an overlap on to the metamorphic rocks. This unconformity is well marked, wherever I have seen an outcrop of Dwyka Conglomerate, either in Zululand or Natal.

The explanation of this unconformity given by Professor Corstorphine, is exceedingly likely to be the true one. It remains thus, that here, in Natal our Dwyka Conglomerate corresponds to the northern glacial conglomerate of the Cape, and has been due to terrestrial glaciation. So far, I have seen no examples of the glacial conglomerate resting comformably on any of the older rocks in Natal or Zululand.

Palæozoic Sandstones.

The outcrop of the horizontally-bedded Palæozoic Sandstones covers a large portion of the area mapped. They are of all textures, from locally-coarse conglomerates down to fine-grained and compact sandstones. They rarely are quartzitic, this only occurring in the immediate vicinity of intrusive volcanic rocks. The prevailing colours are grey, white, and pink. Some beds are very felspathic, particularly those at the base of the series, where they rest immediately upon the granites and metamorphic rocks, from which the materials for their formation have been locally derived. Examples of these felspathic beds can be observed in the upper parts of the Hlangwini valley, and also near the top of the road passing out of the Glendale valley to the south. As a rule they are much jointed, both vertically and horizontally, but faulting is rare, and displacement of strata still rarer, The Sandstones forming the upper scarp of the Glendale valley have a slight dip to the south-east. This dip is fairly general over the area of outcrop, and, although near the coast the coal-bearing series overlying the Dwyka Conglomerate varies much in local dip, the general dip of the Dwyka Conglomerate, and that of the sandstones, have probably been due to the same cause, and occurred at the same time. It is rarely that shales occur associated with those sandstones, and, when they are present, they are purely local in their development, and the individual shale-beds never exceed more than a few inches in thickness,—in fact, they are little else than shaly partings between the thick beds of sandstone. They always exhibit false bedding, showing that they were deposited in shallow water, probably in an estuary or lake. This being the case, it is all the more surprising that the fossil remains of plants and animals are of so rare an occurrence that, as yet, we practically know nothing as regards the palæontology of the series, and, therefore, their correlation with either the Table Mountain Sandstones or the Witteberg Series is at present impossible. They are so ferruginous in places that they form a distinctly

chocolate-coloured soil, exactly like that resulting from the decomposition of basalt. This is particularly the case in the district around Goble's.

Where they have been denuded, in the formation of the river valleys which traverse their outcrops, they form as a rule on the course of the minor rivers especially, deep gorges with precipitous sides. This is well seen on the Isani river, a tributary of the Umvoti. In the Glendale Valley, where the sandstones are comparatively thin, and have formed a capping to the metamorphic rocks below, which have been deeply eroded in the formation of the valley, the sandstones present a precipitous face on the upper edges of both sides of the valley, as far up as the opening into the Hlangwini valley on the north. On the south side this precipitous sandstone outcrop persists southward past the sources of the Umhlali and Tongaat rivers. Here the opposite outcrop to the west, which was once continuous across the intervening low metamorphic country, forms the Great and Little Noodsberg.

Associated with the Palæozoic Sandstones, in many localities, quartz reefs and veins occur. These are often auriferous, and in some places have been worked to a limited extent. One position, where a considerable amount of prospecting work has been done, is on the late Mr. Ritchie's farm, in the north-west corner of the block known as Chaka's Kraal. Here a large number of shafts have been sunk, and most of the alluvial of the valley has been passed through the sluice boxes, by Mr. Ritchie. Many of the quartz veins were very rich in gold, and good specimens were of common occurrence, but in every case the veins gave out at no great depth. The reason of this is not far to seek, in the case of those veins opened up by Mr. Ritchie, and is perfectly applicable to the majority of other veins which occur in this series of Palæozoic Sandstones. It is this, that they invariably occur in the joints which are so common in this formation. These are, as a rule, vertical, and where the individual beds are of any thickness, horizontal jointing occurs, and therefore, in almost every case, the veins occurring on the vertical joints are cut off by the horizontal jointing, as it is commonly the case that the vertical joints do not persist to any extent through either the horizontal bedding or jointing. Fractures of considerable extent, however, sometimes occur in this formation, although rarely. One is to be seen immediately to the north-west of Mr Ritchie's farm, and an extensive outcrop of quartz and pyritic quartzite. The outcrop extends from near the mill, across country to the valley of the Umhlali river, a distance of over a mile, and is traceable on the surface by a well-marked quartz outcrop all the way. This reef has been prospected by Mr. Ritchie and others, but, so far, no encouragement has been obtained, by the discovery of the occurrence of traces of gold, or other metal, to induce the prospectors to proceed further with the exploitation. Rich specimens of auriferous quartz are even yet being picked up in the immediate neighbourhood, but none of them can be traced with certainty to this large lode, which, however, contains a considerable quantity of pyrites. All the gold that I have seen in the rich specimens has not the appearance of gold which has been left by the decomposition of pyrites, but appears to be of a very

are covered with thorn, but, except in the immediate vicinity of the river the native population is very scarce.

Speaking generally of these metamorphic areas, they consist chiefly of granite, with micaceous and hornblendic gneisses and schists, accompanied by heavy basic intrusive rocks, together with dykes of intruded basaltic rocks. The occurrence of the granite is, to a large extent, local. It is usually a coarse rock, containing largely porphyritic triclinic felspars. In the Hlangwini valley, it is garnetiferous. One area of it occurs in the Hlangwini valley, but this is probably connected with the Mapumulu area. Another area of it occurs to the east of the Noodsberg, in the Isidumbeni district, and stretches southwards, at least to the Umhloti. In the valley of the Umvoti river, this area is separated from that of Hlangwini valley, by a belt of highly metamorphosed gneisses.

In the upper portion of the Hlangwini valley, just below the denuded outcrops of the Palæozoic sandstones, traces of gold have been found, by Mr. Thring. It occurs, in a few localities in the joints, which are often much crushed in the granite. One of these is shown on plate v., fig. 1. In the majority of these cases, there are no evidences of the presence of any well-defined fracture, or any body of ore stuff likely to carry gold in any quantity.

In the granitic portion of the area, natural monoliths of granite are not infrequent. These are the undecomposed remains of the granite massif, which has resisted decomposition, while the surrounding decomposed granitic material has been gradually removed, by the denuding agencies, mechanically and in solution. Good examples of these occur in the Hlangwini valley, to the north of Glendale, and a particularly large one exists close tot he road, between Isidumbeni police-station and the Great Noodsberg (Pls. xii., Figs. 1 and 2). This is rather a remarkable specimen, not only for its very large size, but from the fact that it rests upon smaller granitic blocks, thus enclosing beneath it a cave-like shelter of considerable size, and recalling forcibly to one's mind, the ancient prehistoric Dolmens of Northern Africa, and the Druidical Monoliths of Northern Europe. (Pls. xi., Fig. 1).

Small inliers of Metamorphic rocks occur in a few places within the area of outcrop of the sandstones. These are at Reit Valley, at the junction of the two branches of the Itsani river, and on the Tongaat river, near the north-western boundary of Doorn Kloof. These outcrops are of small extent, and are not of any importance economically, except perhaps, that in the case of Reit Valley, the soils which cover the flat, where a good part of the Metamorphic exposure is, are of fairly good quality.

Volcanic Rocks.

The volcanic rocks of the district are all intrusive, and consist chiefly of basaltic rocks. They are very general in their distribution, and occur among all the formations. In their petrological characters they differ widely, from a glassy rock showing incipient crystallisation, to a largely crystalline dolerite. There are many varieties between these two extremes of structure. I hope to describe these at a later

date, when I have been able to make a proper microscopical examination of them.

Economics.

As regards the occurrence of ore-deposits of the heavier metals, there are few records of their presence. With the exception of the auriferous reefs, and accompanying alluvials, previously mentioned in this report, and worked by the late Mr. Ritchie, there is no other part of the district from which traces of gold, or other metalliferous ores have been obtained, sufficient to induce further prospecting. If we take the various formations individually, we find that with the very rare occurrence of reefs in the Dwyka Conglomerate, and its overlying shales, we have the frequent presence of quartz reefs, many of them carrying traces of gold, in the joints of the Palæozoic Sandstones, while there are occasional outcrops, in the same formation, of reefs of considerable extent, and of the character of true fissure veins, but rarely showing even traces of metalliferous ores. Quartz outcrops occur in various portions of the district. They are most common in the Palæozoic Sandstones, and occur at Mr. Ritchie's farm Umhlali, east of Ocean Lodge, and south-west of Kearsney. One is present close to Stanger, where it occurs on the junction line, between the Dwyka Conglomerate and a basaltic rock. In all these cases, there are no evidences of the presence of minerals of any value.

As a rule, the intrusive basaltic rocks which occur so frequently over the district, although of a heavy basic character, rarely or never contain the ores of metals of economic value, and it is rather an uncommon thing to find that they even contain veins or reefs of quartz. In a few instances, among the basaltic intrusions on the coast at Umhlali, veins of calcite of considerable extent are present. I would, however, point out, in reference to these volcanic rocks, that frequently they have, associated with them, superficial deposits of iron ore, which has been chiefly derived from their degradation. It is no uncommon thing to find, in other countries, that such superficial ferruginous deposits often contain, as one of their chief constituents, an ore of Aluminium, Bauxite ($Al_2. O_3. 2H_2. O$). This is the chief ore for the production of Aluminium.

Looking at this district from a mining point of view, I do not think, after the minute examination I have made of it, that it presents any particular evidence to show that it will ever be a mining district of any importance. It is true that, in the southern coastal part of it, coal-measures occur over a limited area, among which thin coal-seams have been proved to exist; but, wherever these have been struck, they have been found to be, for all practical purposes, useless, because of the thinness of the seams and the poor quality of the coal. These coal-measures undoubtedly belong to the Ecca Series, and are, therefore, equivalents of the Zululand coal-measures, and probably they will be found, when opportunity offers to have them worked up, to be also equivalents of the York and Estcourt Series of coal-bearing rocks.

With reference to the granitic area forming the Glendale and Hlangwini valleys, there is little evidence pointing to the prospective development of mining there.

NECESSITY

FOR A

NATAL MUSEUM.

MUSEUM ACCOMMODATION.

In this, the first report of the Geological Survey, I would like to make a few remarks on the subject of museum accommodation for the collections which will be made during the geological survey of the Colony. Such collections usually find a place in the National Museum of the country or state of which the survey is being made. As no such museum exists here, the question necessarily arises as to what facilities the Government are willing to give, for the permanent public exhibition of these specimens, after they have served the purposes of study, for which they were brought together by the survey.

That large collections of rocks, fossils and mineral specimens, have to be made during the examination of the country, prior to the actual geological mapping, is a *sine qua non*. Upon the examination of these specimens and the conclusions deducted therefrom, largely depends the interpretation of the geological history of the area from which they were taken. Although these specimens serve a most important use as affording a basis for geological research in the construction of geological maps and sections, there is yet another and doubtless as important a use to which they should afterwards be put. That is, that they be classified, labelled and exhibited to the public, not only that those who wish may follow the conclusions arrived at by the Geological Survey, but also that, classified and labelled in a properly scientific manner, they may be available for reference or comparison, to aid the student in his study of geology and afford a knowledge of the rocks of the Colony to others, such as builders, engineers, architects, &c., to whom such knowledge will be of great service in the carrying out of their professions.

Under existing circumstances, the housing of this collection brings up the broader question, of the establishment of a National Museum, which would contain collections representing our local industries and natural resources, together with those of the scientific departments of the service, and including such foreign material as would be of importtance and utility to the students of both science and the arts.

In every civilised country there is, at least, one State-aided National Museum, while in many there are subsidiary museums in almost every large town of any importance. In all European countries and in most American states such is the case. Coming nearer home not only has the Cape Colony a large State-aided museum in Cape Town, but many of the smaller towns throughout the Colony possess small museums, which in some cases are more than local in the character of their collections. Even long prior to British ascendency over the Transvaal,

the conservatively-minded Boer Government saw the utility and the advantages to be derived from the establishment of such an institution, with the result that Pretoria possesses a museum of considerable pretensions. In the Native States of India, where the white population is in a very small minority—for instance, in the State of Jeypore—the people possess a museum, supported by the ruler of the state, which, for architectural design, appropriate fittings, method of displaying the specimens and management, will compare favourably with many of our more pretentious European museums. In Mexico, in Brazil, in every Australian Colony, and in New Zealand, a State-aided museum exists, whose educational value has not only been recognised, but appreciated to such an extent, that not one of these Governments would dare to cut off supplies and allow such an institution to become inefficient for want of Government support. Instances of this kind could however be multiplied to any extent, but I think these few will suffice.

It seems somewhat of an anomaly that a Colony so far advanced in civilisation as Natal, and possessed of such a wealth of high-class educational establishments, does not possess a National Museum. Looking at a museum from a purely educational point of view, there is no doubt that it forms one of the most important factors in the education of youth. Its value as an aid, and that an essential one, to the necessarily abstract teaching of the schools and colleges, is inestimable. Within late years this has been brought forcibly before the public by the efforts of all teachers to introduce a more concrete system of education into the schools. Even this, however, does not lessen the value of a museum, conducted upon scientific principles, as a great factor in education.

As a practical illustration of the disadvantages resulting from the absence of a National Museum in Natal, I give the following. A considerable number of the youth of Natal take a University course at the Cape University, and many of them take up the study of such scientific subjects as zoology, geology, mining, &c. Now, these subjects can not be studied, even in an intelligent, let alone a thorough way, without the facilities for study afforded by properly arranged museum collections. During the recess most of these youths return to Natal, and are thereby put at a great disadvantage, as compared with the youth of Cape Colony, from the fact that, by the absence of a National Museum in Natal, they are, to all intents and purposes, debarred, during the lengthened period of their vacation, from carrying on the study of those subjects which require the student to become familiar with actual specimens of the forms of which the subject treats.

One of the chief scientific uses of a museum is that it affords a place for the safe keeping and preservation of all unique, interesting and peculiar specimens, arranged and exhibited in a properly scientific manner, and always accessible to the public for inspection or study. I am sure it will appear desirable that, where such unique specimens and type specimens, from which a new genus or species has been described, have been obtained locally, there should be a National Museum in which they could be deposited and retained in the

Colony, instead of being preserved in museums, in other parts of the world, where no local interest attaches to the specimens. At the same time, it is absolutely necessary that such type specimens be deposited in a museum where they would be easily accessible to all persons who may be studying that branch of the science to which they belong. The state of the case here, at present, is, that the systematic study of the zoology, entomology, conchology, geology, &c., &c., of this Colony and Zululand, have, as yet, been most limited, with the necessary consequence, that it is rare that any collections are made, which do not show, in the hands of a competent scientist, a remarkable assemblage of forms which differ from the corresponding forms of other countries, and in many cases are new to science. What has been done in the investigation of our flora and fauna has been almost entirely due to the enthusiasm of private individuals, resulting necessarily in many of the most interesting and important specimens having found their way into foreign museums and private collections in other parts of the world. No doubt the Natal Society's collection, and that in the Town Hall in Durban, so well looked after by Mr. Quekett, under the most disheartening difficulties of the want of space, and money, have between them a fairly representative collection of the fauna of Natal, with some outside specimens from other parts of South Africa and other countries; but the uselessness of these, under the present circumstances, must be apparent to every one, when it is considered, that what specimens it is possible to exhibit, are in so crowded a condition that they are useless for purposes of study. Those specimens which cannot be shown, for want of space, may, I hope, be of use to posterity.

The formation of small museums is not desirable, at least, until such time as the central National Museum has been established on a proper basis and will be in a position to distribute its surplus duplicate specimens.

At the present time, a fitting opportunity presents itself, to encourage the Government to move in the matter of the establishment of a National Museum. The Natal Society have, for a number of years, taken on their own shoulders, a responsibility, which, in almost every other civilised country has been undertaken by the Government, that is, the housing and upkeep of a collection, for exhibition to the public, chiefly consisting of natural history, geological, and antiquarian specimens, indigenous to the Colony. The Natal Society's collection, has gradually grown to such proportions, that, after years of defeated effort to exhibit the specimens to the best advantage, in a room totally inadequate for the collection, both as regards space and light, the Society find, the increased accommodation required for the enlargement of the library, necessitates doing away with the museum, as a museum. Under these circumstances the Society has, almost unanimously, and with a public generosity that is to be commended, offered the collection as it stands, as a free gift to the people of Natal, on condition that the Government provide the necessary accommodation or the collection and for its future expansion. There is no doubt that he specimens, if taken over by the Government, would form the admirable

SCHEME FOR THE CARRYING ON OF THE GEOLOGICAL SURVEY.

In reference to the carrying on of the Geological Survey in the future, I would suggest the following general scheme.

As the chief object of the Geological Survey of the Colony, is to obtain a knowledge of the natural resources of the country, so that localities may be indicated, in which there may seem a prospect of opening up, and successfully developing industries, particularly mining industries of all kinds, the individual efforts and working methods of the survey must be, to a large extent, adapted to the accomplishment of this object. This being the case, the first essential is to obtain a knowledge of the general geology of the country, so that likely areas may be selected, which may prove, after detailed survey, to contain minerals of economic value. This is, of course, more applicable to unknown countries than it is to Natal, for instance, which has already had, years ago, a certain amount of geological attention paid to it, and a rough idea of its general geology can be obtained from the writings of the earlier observers. In Zululand, however, it is different, for there, few geological observations have previously been recorded, and its general geology is practically unknown. For this reason, some two years ago, I started a reconnaissance survey of the Province of Zululand, but was prevented from getting over more than half of the country, owing to the outbreak of war with the Dutch Republics. The finishing of this preliminary survey of Zululand, should be undertaken as soon as it is feasible. In fact, I would suggest, that, as soon as the necessary preparations for a start are completed, I should use, at least, a portion of the coming season, in furthering the reconnaissance survey of Zululand. It is very essential that such preliminary work should be undertaken, in the early years of the Geological Survey. On the completion of this reconnaissance work, a knowledge will have been obtained of the general geology of the province, and its relations to the geology of the neighbouring countries. It will then be possible to define, in a general way, the areas which are occupied by the various formations, and thereby indicate those areas under which coal may be expected to occur, together with those areas, which are occupied by rocks, in which there is a possibility of the occurrence of lodes, containing ores of the heavier metals. This knowledge, in itself, would, to a very large extent, prevent the useless expenditure of both money and time, in prospecting for various minerals and ores among rocks, in which they are never known to occur.

The work to be undertaken by the survey in the prosecution of the geological mapping of the country is divisible into two kinds: the one dealing with the investigation and mapping of the older sedimentary,

metamorphic and crystalline rocks ; and the other, the mapping of the coal-bearing formations. It would be of great advantage if the geological staff were large enough to admit of both these surveys being carried on simultaneously ; but, with only one geologist, this is almost impracticable, as he would otherwise have to devote part of his time in each year to each separate class of work. This, in itself, is a most unsatisfactory method to employ with the hope of doing lasting and good work. We have such a large area, both in Natal and Zululand, in which coal-bearing series of rocks are present, that it is a most important matter that an accurate knowledge be obtained of these rocks among which so valuable an asset as coal exists. It is a commonly-accepted idea among colonists here that this vaguely-defined area of coal-land needs no further attention than that given to it when a new company or syndicate makes itself known as a probable new investment. There is no question of doubt that large portions of these coal-bearing series of rocks are barren of productive coals. In many cases this is due to the extreme denudation of the series, and, in others, it is due to the fact, as I have pointed out elsewhere in this report, that many of our coal-seams were deposited in local basins, and, therefore, occupy circumscribed and isolated areas.

That it is necessary to have these areas accurately defined, and an intimate knowledge acquired of the succession of the coal-bearing series, with its systems of intrusive rocks, faultings, &c., must appear to anyone, even possessing no geological knowledge, to be a common-sense and business-like conclusion. Associated with the coal, in the same series of rocks occur other mineral products in the form of iron ores and limestones which have frequently proved, in other parts of the world, as valuable, if not more so than coal. Many such deposits are known to occur in various parts of the coal-bearing area of Natal and Zululand, but there is little else known concerning them than an ill-defined locality. It is reasonable to suppose that the people of Natal, through their government, desire the development of the natural resources of their country, and, I daresay, from a personal point of view, the sooner the better, so that they may, individually, participate in the advantages accruing therefrom. As a preliminary to such development, the chief thing necessary is a knowledge of the actual facts which lead up to such development, and these are an accurate and thorough knowledge of the geology of the country, its minerals and ore-stuffs, and their capacity for profitable development. The attainment of this knowledge, even by the employment of the most advanced methods of geological surveying, must necessarily be a slow process, particularly when the country is a large one, and the geological staff is limited in numbers.

With reference to the examination and mapping of the areas, occupied by the older sedimentary and crystalline rocks, it would be advisable to have this work done independently of the other, mentioned above. In order to do this, and carry out the general work of the Survey, on the lines which I have sketched out, it would be necessary to increase the geological staff, with an accompanying increase of expenditure. I would suggest that two geological surveyors, at least, be employed, besides the Government Geologist. They ought to be men who have

had the advantages of an education, specially adapted to the geological profession, with considerable experience in field-work, because at this stage of the survey, it is impossible to carry out the necessary work, and at the same time, train youths to the profession. What is wanted is that the geological assistants, should be men who could, immediately upon their appointment, be entrusted to do independent work, instead of having to serve years of probation.

With the enormous increase of scientific knowledge, within the last few decades, the specialisation of the various branches of each science, has developed accordingly. It is therefore advisable, in the selection of men, to form a geological survey staff, to obtain men, who, individually are specialists in the various branches of the science.

With such an increase to the staff as I have suggested, I would propose to employ them according to the general plan I have stated above, utilising their special qualifications as far as possible. As regards the special qualifications which would be most useful here, I think that, given the necessary geological experience, a special knowledge of chemical analysis and mineralogy in the one case, and in the other, a special knowledge of palæontology, would be desirable.

ADDITIONS

TO THE

GEOLOGICAL SURVEY LIBRARY

DURING

1899 AND 1900.

ADDITIONS

TO THE

GEOLOGICAL SURVEY LIBRARY

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Fig. 4—Impression of a complete whorl of linear acicular leaves.
Fig. 5—A less perfect but similar specimen
Fig. 6—Portion of a small stem and collar, with six leaves radiating therefrom. x 2. (Specimen lent by Mr. D. Brown.)
Glossopteris retifera, *Feistmantel.*
Fig. 7—Portion of a frond exhibiting quadrangular, pentagonal, and hexagonal areolæ.
Fig. 8—Some of the areolæ enlarged.

PLATE XIV.—Geological Section from Pietermaritzburg to the Bluff. The igneous rocks are not shown.

PLATE XV.—Section of coal at Morewood Cove, Umhlali Beach, Victoria County, Natal.

PLATE XVI. AND XVII.—Geological coast section from mouth of Tongaat river to mouth of Umvoti river.

PLATE XVIII.—Geological Section along line A.B. on Geological Map of Lower Tugela Division. (Plate xix.)

PLATE XIX.—Geological Map of Lower Tugela Division, Victoria County, Natal.

PLATE XX.—Geological Sketch Map of portion of Zululand.

FIG. 1.

West, Newman collotyp.

FIG. 2.

West, Newman collotyp.

FIG. 1.

West, Newman collotyp.

FIG. 1. Glaciated pavement of Potsdam Mountain Sandstone.

Rhyolite showing flowage structure, picked out by weathering

FIG. 1.

West, Newman collotyp.

Rhyolite [illegible]

FIG. 2.

FIG. 1.

West, Newman collotyp.

FIG. 2.

FIG. 1.

West, Newman collotyp.

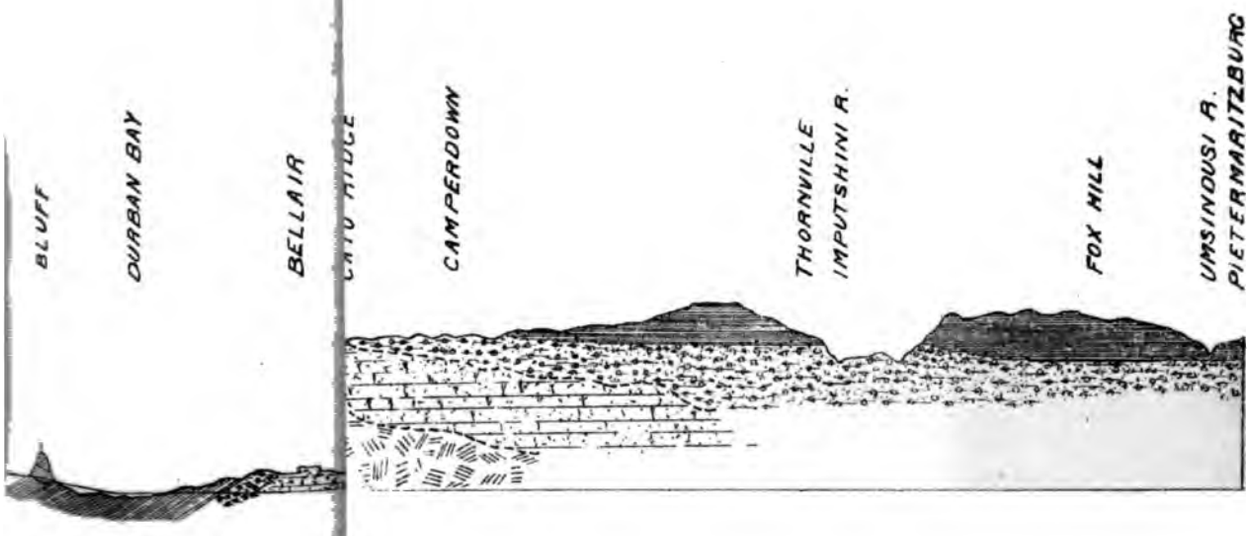
FIG. 2.

West, Newman collotyp.

Glaciated pavement of Potsdam Sandstone. FIG. 1

Head of Mountain Lake, Minn.

IDEAL SECTION PIETERMARITZBURG.



REFERENCE

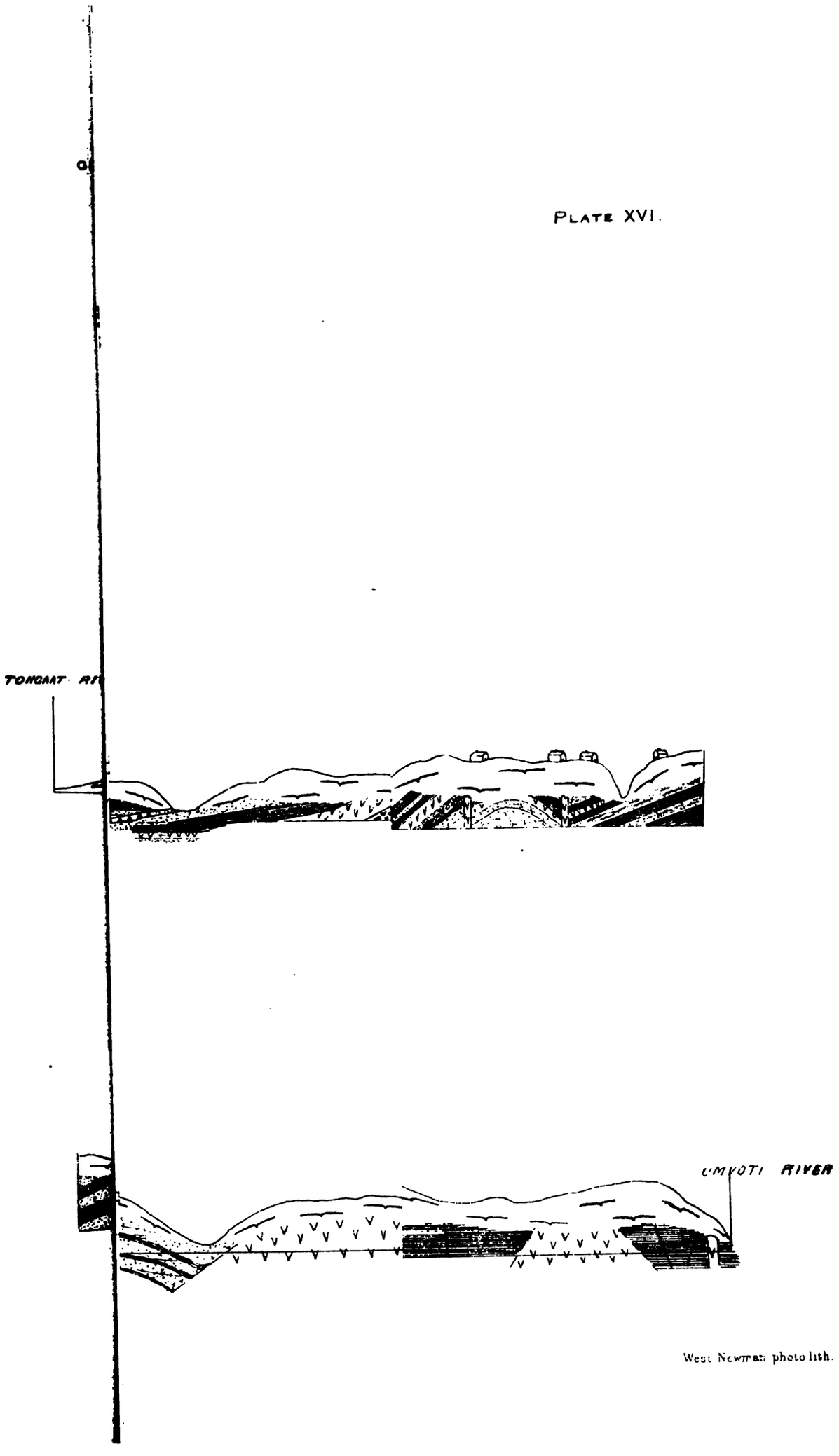
PALAEOZOIC SANDSTONES

GRANITE WITH GNEISSES & SCHISTS

(VN)

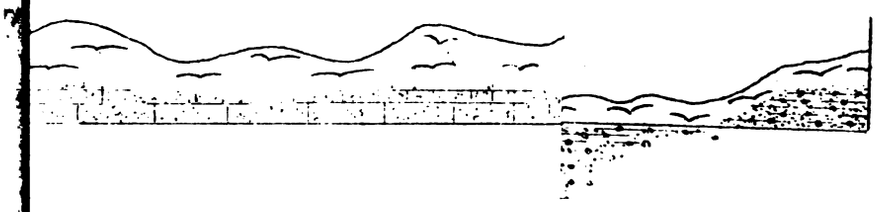
West, Newman photo-lith

PLATE XVI.



West Newman photo lith.

PLATE XVII.



TUGELA RIVER

West, Newman & Wealdith

OL. SUR. OF NATAL

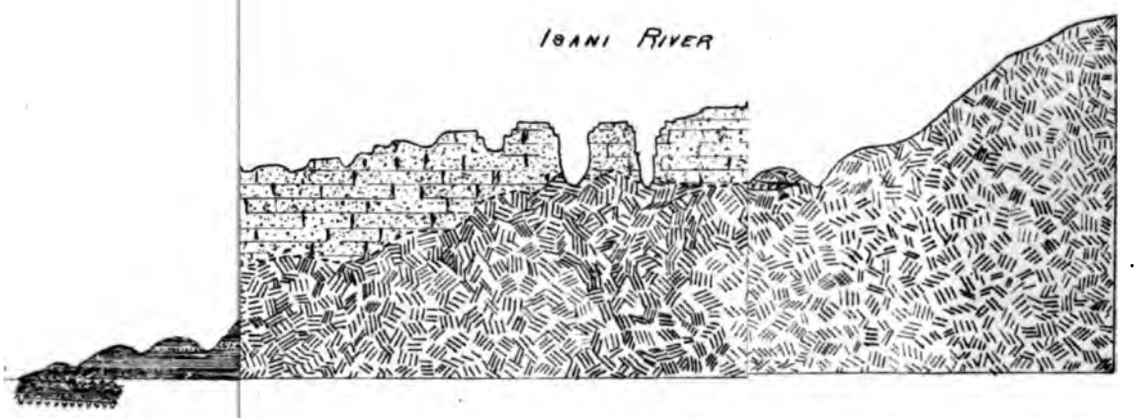
PLATE XVIII :

THE COAST AT UM

AB)

A

B



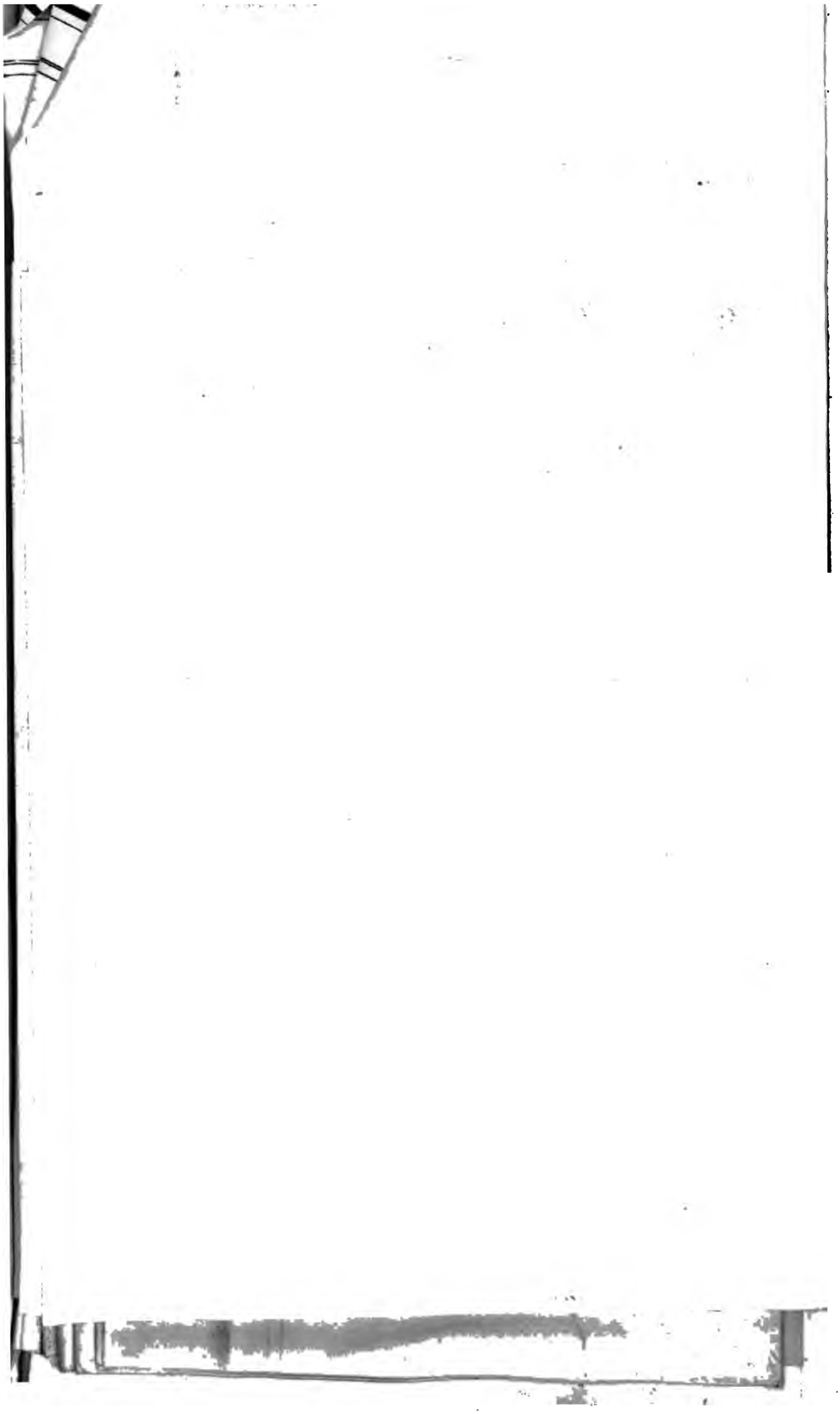
PALAEOZOIC SANDSTONES

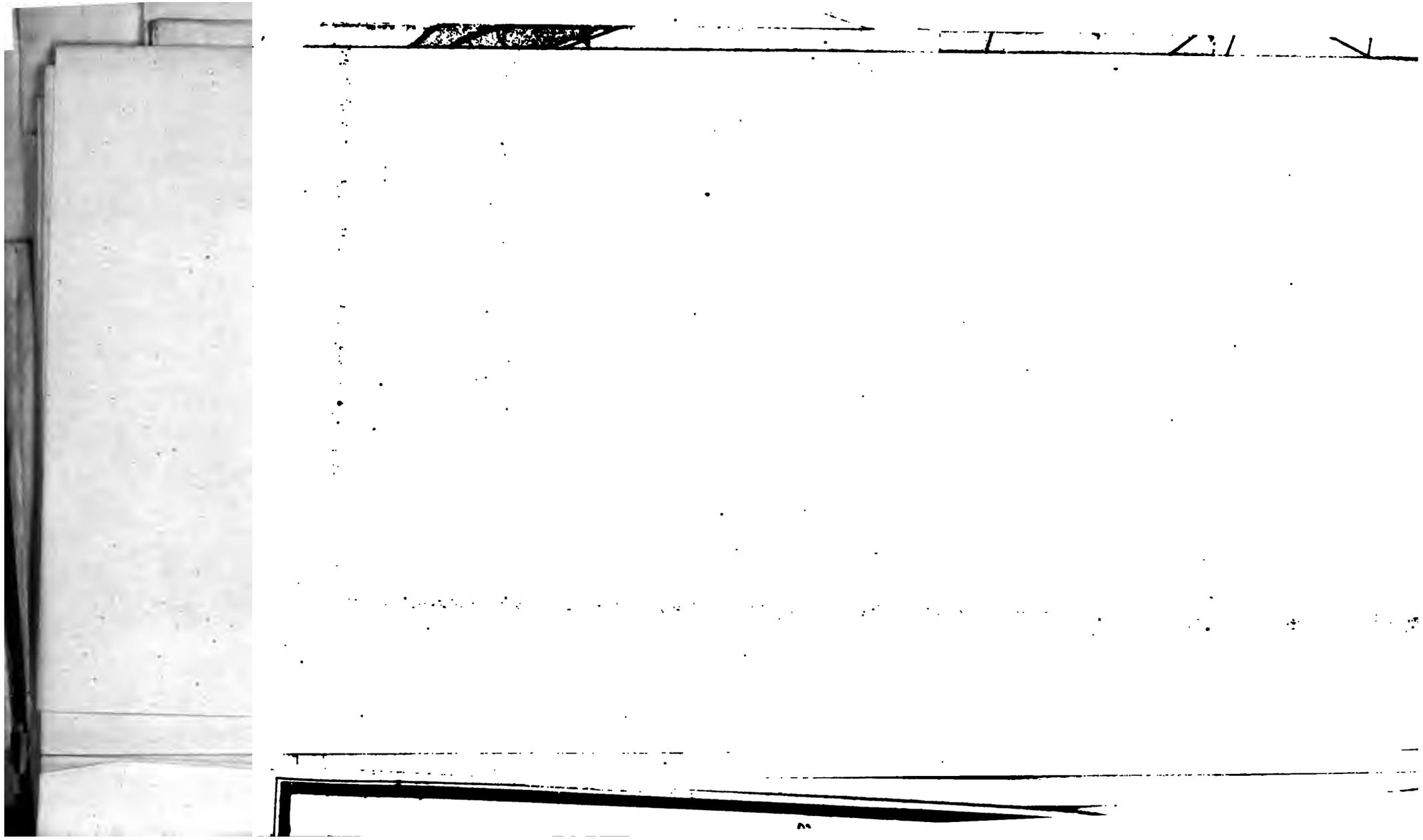
GRANITE WITH GNEISSES AN

FELSITE (INTRUSIVE)

CENE AND RECENT ALLUVIALS

West, Newman photo-lith.





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